



JETLINE™ JL-1 50 WATERJET INTENSIFIER

OPERATION AND MAINTENANCE MANUAL



JETLINE™
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WATERJET
INTENSIFIER

20480269(R03)

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KMT WATERJET SYSTEMS 2009



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TABLE OF CONTENTS

Title Page
Notice
Table of Contents
Appendix

<i>Section</i>	<i>Page</i>
1 Introduction	1-1
1.1 Overview	1-1
1.2 Product Nameplate	1-1
1.3 Operational Overview	1-1
Low Pressure Water System	1-2
Recirculation System	1-2
Hydraulic System	1-2
High Pressure Water System	1-2
Operating System	1-3
1.4 Safety	1-4
Lockout/Tagout Procedure	1-4
Warning Labels	1-5
Emergency Medical Treatment	1-7
1.5 Worldwide Product Support	1-7
1.6 Spare Parts	1-8
1.7 Manual Organization	1-8
1.8 Equipment and Service Manual Questionnaire	1-8
2 Installation	2-1
2.1 Overview	2-1
2.2 Installation Summary	2-1
2.3 Site Requirements	2-2
Transporting	2-2
2.4 Power Requirements	2-3
2.5 Service Connections	2-4
Cooling Water	2-5
Cutting Water	2-6
Drain	2-6
Plant Air	2-6
Contaminated Waste	2-7
2.6 Flow Requirements	2-7
2.7 High Pressure Piping	2-8
Measurements and Dimensions	2-10
Hand Coning	2-11
Power Coning	2-12
Hand Threading	2-13
Power Threading	2-13

2.8	High Pressure Connections	2-14
	Standard Connections	2-14
	Anti-Vibration Connections	2-15
2.9	Commissioning	2-16
2.10	Decommissioning	2-18
3	Maintenance	3-1
3.1	Overview	3-1
3.2	Maintenance	3-1
	Daily Inspection	3-1
	Periodic Maintenance	3-1
	High Pressure System Maintenance	3-2
3.3	Maintenance Precautions	3-3
3.4	Tool Kit	3-4
4	Operation	4-1
4.1	Overview	4-1
4.2	Startup Sequence	4-1
	Startup after Motor Stop	4-1
	Startup after Emergency Stop	4-1
4.3	Keypad and Screen Functions	4-2
4.4	Run Screen	4-3
4.5	System Screen	4-4
4.6	Information Screen	4-4
	Hours Screen	4-5
	Capacity Screen	4-5
	Stroke Rate Screen	4-6
	Date/Time Screen	4-6
	Program Information Screen	4-7
4.7	Settings Screen	4-7
	Stroke Rate Screen	4-8
	Configuration Screen	4-8
	Language Screen	4-9
	Serial Number Screen	4-9
	Date/Time Screen	4-9
	HMI Screen	4-9
4.8	Maintenance Screen	4-10
	Maintenance Hours Screen	4-10
	Maintenance Strokes Screen	4-11
4.9	Alarms	4-11
5	Low Pressure Water System	5-1
5.1	Overview	5-1
5.2	Cutting Water Supply Quality	5-2
5.3	Operation	5-2
5.4	Service and Maintenance Procedures	5-4
	Filter Assembly and Strainer Maintenance	5-4
	Booster Pump Adjustment	5-5

6	Recirculation System	6-1
6.1	Overview	6-1
6.2	Operation.....	6-2
6.3	Service and Maintenance Procedures	6-3
	Hydraulic Oil Maintenance.....	6-3
	Electric Motor Bump	6-5
	Oil Filter Maintenance	6-6
	Operating Temperature Adjustment	6-6
7	Hydraulic System	7-1
7.1	Overview	7-1
7.2	Operation.....	7-2
7.3	Service and Maintenance Procedures	7-3
	Hydraulic Operating Pressure	7-4
	Motor Maintenance.....	7-5
	Hydraulic Compensator Maintenance.....	7-5
8	Electrical System	8-1
8.1	Overview	8-1
8.2	Operation.....	8-1
	Sensors and Solenoids.....	8-4
8.3	Service and Maintenance Procedures	8-8
	Proximity Switch Maintenance.....	8-8
9	High Pressure Water System	9-1
9.1	Overview	9-1
9.2	Operation.....	9-2
9.3	System Components.....	9-4
9.4	Service and Maintenance Overview	9-6
	Torque Specifications	9-7
	Specialized Maintenance Tools	9-8
9.5	High and Low Pressure Water Piping.....	9-9
9.6	High Pressure Cylinder Assembly	9-9
	High Pressure Cylinder Assembly Removal.....	9-10
	High Pressure Cylinder Assembly Installation	9-11
	High Pressure Cylinder Maintenance	9-12
9.7	Sealing Head	9-13
	High Pressure Discharge Check Valve	9-13
	Low Pressure Inlet Check Valve.....	9-15
	Sealing Head Seal Assembly	9-16
	Sealing Head Maintenance	9-16
9.8	High Pressure Seal Assembly	9-17
9.9	Hydraulic Seal Cartridge Replacement.....	9-19
	Hydraulic Seal Cartridge.....	9-20
9.10	Hydraulic Piston and Plungers.....	9-23
	Hydraulic Piston and Plunger Removal.....	9-23
	Bearing Rings and Seal Assembly	9-25
	Plunger Maintenance	9-25
	Hydraulic Piston and Plunger Installation	9-26

9.11	Hydraulic Cylinder Maintenance	9-27
9.12	High Pressure Attenuator	9-27
9.13	High Pressure Dump Valve	9-28
	Pneumatic Control Dump Valve	9-28
	Pneumatic Actuator	9-33
9.14	Weep Holes	9-34
10	Troubleshooting	10-1
10.1	Overview	10-1
10.2	Troubleshooting Guide	10-1
11	Specifications	11-1
11.1	Overview	11-1
11.2	Installation Specifications	11-1
	Environment	11-1
	Sound Level	11-1
	Equipment Dimensions and Weights	11-2
	Service Connections	11-2
	Plant Air	11-2
11.3	Water Specifications	11-3
	Cutting Water Supply	11-3
	Recirculation System	11-3
	Water Quality Standards	11-4
11.4	Electrical Specifications	11-6
	Electrical System	11-6
	Ampacity and Power Voltage Requirements	11-6
11.5	Hydraulic and High Pressure System Specifications	11-7
	Hydraulic System	11-7
	High Pressure Water System	11-7
	Orifice Capacity	11-8
	Torque Specifications	11-9
12	Parts List	12-1
12.1	Overview	12-1
12.2	Index	12-2

APPENDIX

Exhibit

System Schematic
Electrical Schematic
Material Safety Data Sheets



SECTION 1

INTRODUCTION

1.1 Overview

The Jetline™ Series combines all the unique capabilities and advantages of waterjet cutting systems with the reliability, ease of operation and service support that have made KMT Waterjet Systems a leader in waterjet technology.

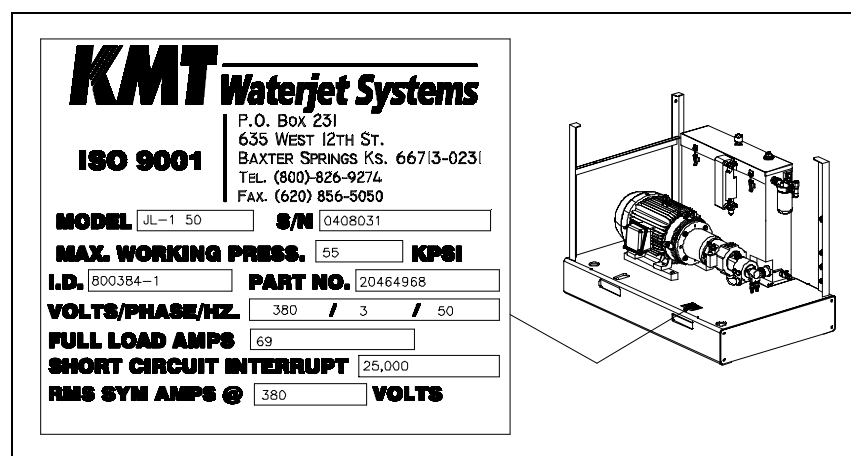
Table 1-1
Jetline™ JL-1

Motor Horsepower Rating		Maximum Operating Pressure	Maximum Flow Rate (at full pressure)	Maximum Single Orifice Diameter (at full pressure)
HP	Kw			
30	22	55,000 psi (3,792 bar)	.60 gpm (2.3 L/min)	0.011 inch (0.28 mm)
50	37	55,000 psi (3,792 bar)	1.0 gpm (3.8 L/min)	0.014 inch (0.36 mm)

1.2 Product Nameplate

The product nameplate contains the pump model, serial, identification and part numbers for each individual machine.

Figure 1-1: Nameplate



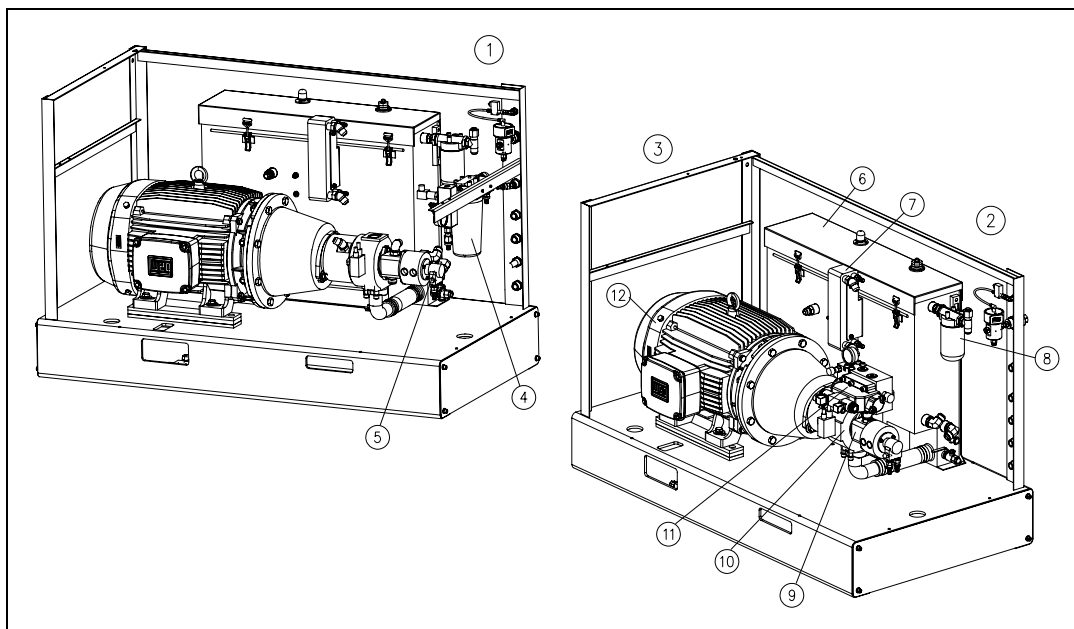
1.3 Operational Overview

The following provides a brief overview of the function and primary components associated with the individual systems. A detailed discussion of each system is provided in Sections 4 through 9. Equipment specifications are provided in Section 11, Specifications.

Low Pressure Water System

The low pressure water system supplies the cutting water flow to the intensifier. Major system components include the booster pump and low pressure water filter assembly.

Figure 1-2: System Components



1 Low Pressure Water System

4 Water Filter Assembly

5 Booster Pump

2 Recirculation System

6 Hydraulic Oil Reservoir

7 Heat Exchanger

8 Oil Filter Assembly

9 Recirculation Pump

3 Hydraulic System

10 Hydraulic Pump

11 Hydraulic Manifold

12 Electric Motor

Recirculation System

The recirculation system is a cooling and filtration system that provides properly conditioned oil to the main hydraulic system. Major system components include the recirculation pump, heat exchanger, oil filter assembly and the hydraulic oil reservoir.

Hydraulic System

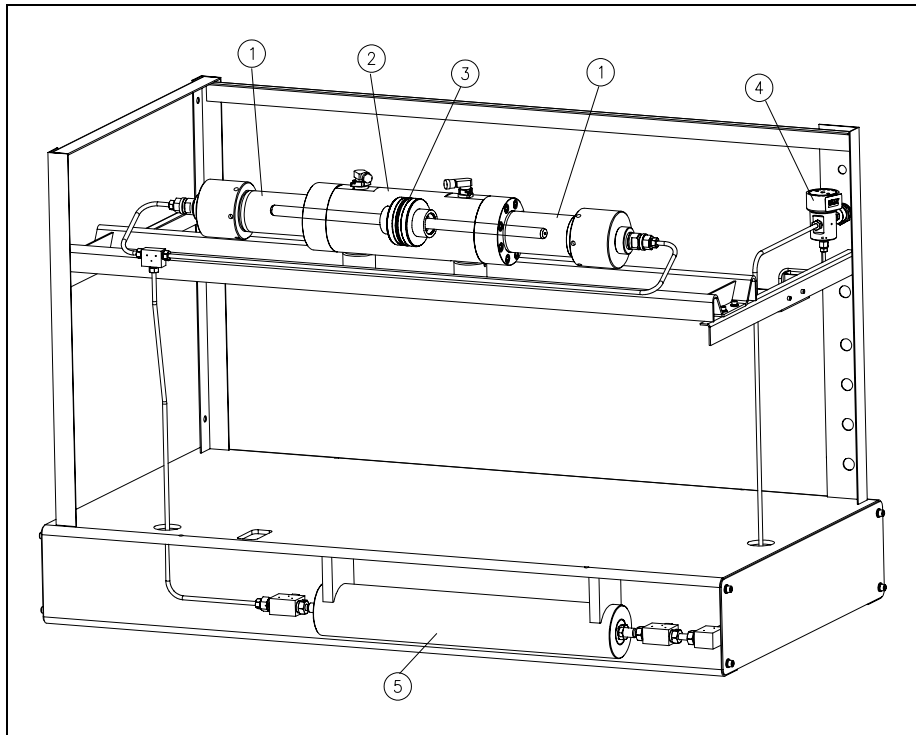
The hydraulic system supplies the intensifier with the hydraulic oil required to produce high pressure water. Major system components include the electric motor, hydraulic pump, and the 4-way directional control valve mounted on the hydraulic manifold.

High Pressure Water System

The high pressure water system is the heart of the waterjet system. Water is pressurized and continuously delivered to the cutting head. As water passes through a tiny hole in the orifice, water pressure is converted to water velocity capable of cutting most any material.

The major components include the high pressure cylinder assemblies, hydraulic cylinder, hydraulic piston, attenuator and the safety dump valve.

Figure 1-3: High Pressure System Components

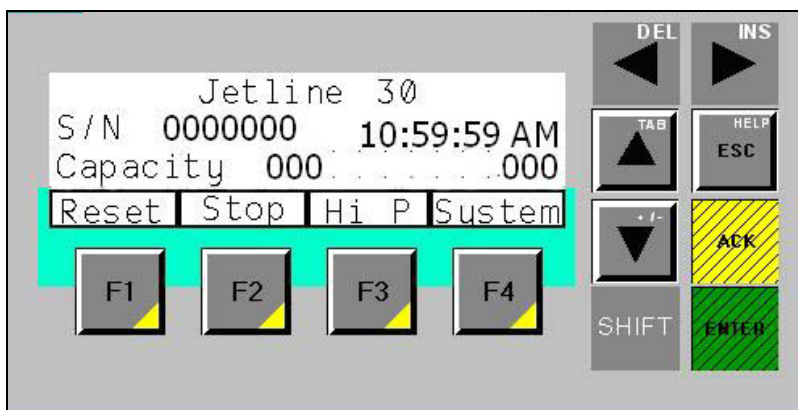


- | | |
|-----------------------------------|---------------------|
| 1 High Pressure Cylinder Assembly | 4 Safety Dump Valve |
| 2 Hydraulic Cylinder Assembly | 5 Attenuator |
| 3 Hydraulic Piston | |

Operating System

A programmable logic controller (PLC) provides basic intensifier shift control and monitors out of limit conditions. Operator interface is through the function-button control panel.


Figure 1-4: Control Panel



1.4 Safety

The high pressure waterjet cutting system is a high energy cutting tool capable of cutting many dense or strong materials. Do not touch or be exposed to high pressure water. High pressure water will penetrate all parts of the human body. The liquid stream and the material ejected by the extreme pressure can result in severe injury.

All personnel operating, servicing or working near the waterjet cutting equipment shall adhere to the following safety precautions, as well as the applicable plant safety precautions.

- Only KMT factory trained, qualified personnel shall service and maintain the equipment.
- The operator shall practice and promote safety at all times to avoid potential injury and unnecessary downtime.
- The operator shall ensure that the work area around the equipment is clean and free of debris and oil spills.
- All protective guards, shields or covers shall be in place on the equipment at all times.
-  Safety glasses and ear protection shall be worn when operating or working near the equipment.

Lockout/Tagout Procedure

This lockout/tagout procedure is designed to protect all employees from injuries caused by the unexpected energizing or startup of the machine, or the release of stored energy during service and maintenance.

This is accomplished with energy isolating devices that prevent the transmission or release of energy. An energy source is any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy source that could cause injury to personnel.

A lockout device utilizes a lock and key to hold an energy isolating device in the safe position and prevents the machine from being energized. A tagout device is a prominent warning device that can be securely attached to the machine warning personnel not to operate the energy isolating device. This procedure requires the combination of a lockout device and a tagout device.

The lockout/tagout procedure applies to any employee who operates and/or performs service or maintenance on the machine. Before any maintenance or repairs are performed, the machine shall be isolated, and rendered inoperative as follows.

1. Shut down the machine by pressing the F1 key and open the high pressure cutting water valve to bleed the water and hydraulic pressure from the system.
2. Disconnect, lockout and tag the main, customer supplied, power source.
3. Lockout and tag the circuit breaker/disconnect on the electrical enclosure door.

4. Close, lockout and tag the manual shutoff valves for all service connections: cutting water in, cooling water in and out, and air.

Warning Labels

Warning labels are posted on the machine to indicate potential hazards. The operator and service personnel shall pay particular attention to these warning labels. Table 1-2 describes the necessary precautions and provides the part number required to order replacement labels.

Table 1-2
Warning Label Precautions



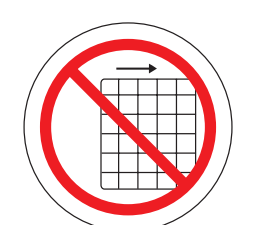
1	 P/N 05114962	<p>The electrical enclosure and motor junction box can present an electrical shock hazard. Always disconnect and lockout the main power before opening the enclosure.</p> <p>Always disconnect and lockout the main power and the circuit breaker/disconnect on the electrical enclosure door before performing any type of maintenance</p>
2	 P/N 05114970	<p>The surface of high pressure water and hydraulic components becomes hot during normal operation. Failed, or failing components, can become extremely hot during operation.</p>
3	 P/N 80082209	<p>Ensure all protective guards, shields or covers are in place on the equipment at all times. Never operate the pump with the guards removed.</p>

Table 1-2
Warning Label Precautions

4



P/N 05098017

High pressure water and/or hydraulic pressure can remain in the system even when the pump has been shut off. All pressure can be safely bled from the system by opening the high pressure cutting water valve for a few seconds after shutting off the pump.

Pressing the EMERGENCY STOP button turns the control power to the intensifier off, stops the pump and bleeds the high pressure water through the safety dump valve.

Depressurization of the high pressure system creates a loud hissing sound when the dump valve opens. The sound fades quickly as the pressure drops.

5



P/N 20415794

All personnel involved in the installation, operation and/or service of the intensifier must carefully read, understand and follow the procedures in this manual to avoid creating unsafe conditions, risking damage to the equipment, or personal injury.

Safety precautions and warnings for specific procedures are emphasized throughout this manual as illustrated in the following examples. These precautions must be reviewed and understood by operating and maintenance personnel prior to installing, operating or servicing the machine. Adherence to all Warnings, Cautions and Notes is essential to safe and efficient service and operation.



WARNING

Warnings emphasize operating or service procedures, or conditions that can result in serious personal injury or death.



CAUTION

Cautions emphasize operating or service procedures, or conditions that can result in equipment damage or impairment of system operation.

NOTE

Notes provide additional information that can expedite or improve operating or service procedures.



Emergency Medical Treatment

An emergency medical card is included in the binder of this manual. This information should be used to aid in the treatment of a waterjet injury. Additional cards may be obtained by contacting KMT Waterjet Systems using the address or telephone number shown on the card.

Medical Alert

This card is to be carried by personnel working with high pressure waterjet equipment. Obtain medical treatment immediately for ANY high pressure waterjet injuries.

KMT Waterjet Systems
635 West 12th Street
Baxter Springs, KS 66713
(620) 856-2151

This person has been working with water jetting at pressures to 60,000 psi (414 MPa, 4137 bar, 4,218 Kg/cm²) with a jet velocity of 3,000 fps (914 mps).

Foreign material (sand) may have been injected with water. Unusual infections with microaerophilic organisms occurring at lower temperatures have been reported, such as gram negative pathogens as are found in sewage.

Bacterial swabs and blood cultures may therefore be helpful. This injury must be treated as an acute surgical emergency and be evaluated by a qualified surgeon. Circulation may be compromised, therefore, DO NOT APPLY HEAT TO INJURED PART. For first aid: (1) Elevate injured part (2) Antibiotics (3) Keep injured person NPO.

1.5 Worldwide Product Support

The KMT Waterjet Customer Service Department is available to answer your questions regarding equipment installation and service. Technical assistance is available by phone and on-site support is available on request.

On-site technical assistance is available during equipment installation and startup. Additionally, technical support for service and maintenance issues and training of operators and maintenance personnel is available. Periodic training sessions are also conducted at KMT Waterjet and customer facilities.

Contact the KMT Waterjet Customer Service Department for additional information.

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1.6 Spare Parts

KMT Waterjet maintains a well-stocked Spare Parts Department, staffed by trained, knowledgeable personnel. If required, emergency shipment is available. Contact the Customer Service Department to order spare parts, or for additional information.

1.7 Manual Organization

This manual contains operating and maintenance procedures for the Jetline™ Series. Information is organized as follows:

- Section 1, Introduction, provides an overview of equipment features and options, a brief operational overview, details regarding safety issues and contact information for product support.
- Section 2, Installation, details installation requirements and procedures. Systematic guidelines for commissioning the intensifier are also provided.
- Section 3, Maintenance, highlights routine and preventive maintenance requirements. Precautions associated with high pressure cutting equipment are also reviewed.
- Section 4, Operation, explains the control functions and the display panel where operating parameters are set and monitored.
- Sections 5 through 9 are specific to each individual system. Each section contains a detailed description of the principles of operation and the function of each system. Routine maintenance procedures associated with the system are also detailed.
- Section 10, Troubleshooting, is a comprehensive guide containing the information required to diagnose problems and repair the machine.
- Section 11, Specifications, contains a comprehensive list of equipment specifications; a detailed discussion of water quality standards and treatment guidelines; as well as horsepower requirements for various orifice sizes.
- Section 12, Parts List, contains part numbers, descriptions and drawings to facilitate the ordering of replacement parts.

1.8 Equipment and Service Manual Questionnaire

We are interested in your impression of the KMT Waterjet System recently installed at your location. Your comments and recommendations will aid us in our continuing goal to improve our products, and make our technical information more useful to our customers.

At your convenience, please take a few minutes to complete the following questionnaire, and return it to the applicable Customer Service Department listed above.



Equipment and Service Manual Questionnaire

1. General Appearance

Was the unit received in good condition?

☐ Yes ☐ No

Comments: _____

Is the unit a convenient size?

☐ Yes ☐ No

2. Controls

Are the controls user friendly?

☐ Yes ☐ No

Is the unit easy to operate?

☐ Yes ☐ No

Comments: _____

3. Performance

Does the unit perform smoothly and meet your expectations?

☐ Yes ☐ No

Does the unit run quietly?

☐ Yes ☐ No

Comments: _____

4. Did the installation and startup go smoothly?

☐ Yes ☐ No

Comments: _____

5. What features do you consider the most significant?

Quiet operation _____

Appearance _____

Performance/Operation _____

Repair/Maintenance _____

Other _____

6. What areas could be improved?

Appearance _____

Performance _____

Serviceability _____

Other _____



7. Manual Organization

Does the Table of Contents help you find topics easily? ☐ Yes ☐ No

Comments: _____

Is the information well organized? ☐ Yes ☐ No

Comments: _____

Is the page layout suitable for the material being presented? ☐ Yes ☐ No

Comments: _____

8. Graphics

Are the illustrations suitable for the material being presented? ☐ Yes ☐ No

Comments: _____

9. Text

Does the information adequately explain how to operate and service the equipment? ☐ Yes ☐ No

Comments: _____

Are there paragraphs or procedures you feel need clarification? Please identify them by page number and add your comments. ☐ Yes ☐ No

Comments: _____

Is there anything you would add or delete to make the manual more useful? ☐ Yes ☐ No

Comments: _____

Is there any information that should receive more emphasis? ☐ Yes ☐ No

Comments: _____

Name	_____	Title	_____
Company	_____	Date	_____
Address	_____		



SECTION 2

INSTALLATION

2.1 Overview

Installation and commissioning requirements and procedures are detailed in this section. These procedures require a thorough understanding of the individual components and systems, safety issues, and the overall operation of the intensifier.

All personnel involved in the installation, operation and/or service of the intensifier must carefully review this manual prior to installing and commissioning the machine.

The Technical Service Department at KMT Waterjet Systems is available to assist in the installation and commissioning process. Service and repair training for maintenance personnel is also available.

2.2 Installation Summary

The following summary lists the procedures required for the installation and commissioning of the intensifier system. Details and requirements for each item are discussed in this section.

- Upon receipt, the machine must be uncrated and moved into position on a level surface.
- Properly sized power drops with fused disconnects must be installed.
- A pneumatic drop with a manual shutoff valve and regulator for the air connection must be installed.
- Plumbing and manual shutoff valves for the inlet and outlet cooling water, and the inlet and outlet cutting water must be installed.

Incoming source water must meet specific water quality standards, flow rates and pressure requirements. It may be necessary to install water conditioning and/or pressure boosting equipment to meet these water purity and pressure requirements.

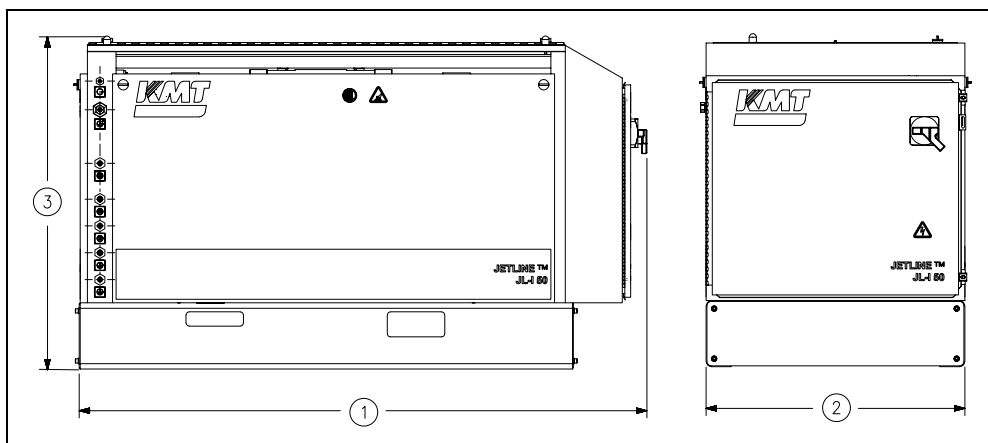
- Drain water plumbing must be suitably located and installed for the proper disposal of wastewater.
- High pressure tubing runs from the intensifier to the cutting station must be installed with the appropriate mountings, support brackets and hardware.
- Wiring must be installed and connected between the intensifier and the cutting station control system.
- The machine must be commissioned and tested.

2.3 Site Requirements

The intensifier must be installed indoors where air borne dust and contaminants are minimal. The ambient temperature should be between 40° F (5° C) and 104° F (40° C), with a maximum relative humidity of 95 percent.

Refer to Table 2-1, Equipment Dimensions and Weight, to establish a suitable installation site. A minimum clearance of 36 inches (914 mm) should be provided on all sides of the machine to facilitate service.

Figure 2-1: Equipment Dimensions



**Table 2-1
Equipment Dimensions and Weight**

Model	(1) Length	(2) Width	(3) Height	Weight
JL-1 30	78.98" (2,006 mm)	36.00" (914 mm)	46.58" (1,183 mm)	2,450 lbs (1,111 kg)
JL-1 50	78.98" (2,006 mm)	36.00" (914 mm)	46.58" (1,183 mm)	2,650 lbs (1,202 kg)

Transporting

The weight of the machine is not evenly distributed from one end to the other. Do not attempt to lift the machine from either end. Note the warnings stamped on the crate. The center of gravity is clearly identified on the sides of the crate. The forklift should be positioned accordingly.

When the machine has been removed from the crate, note the position of the fork pockets on the bottom of the machine. The pockets are positioned in relationship to the center of gravity to balance the weight on the forklift.



Position the forklift carefully to avoid damage to the high pressure attenuator and high pressure tubing.

Figure 2-2: Fork Pockets

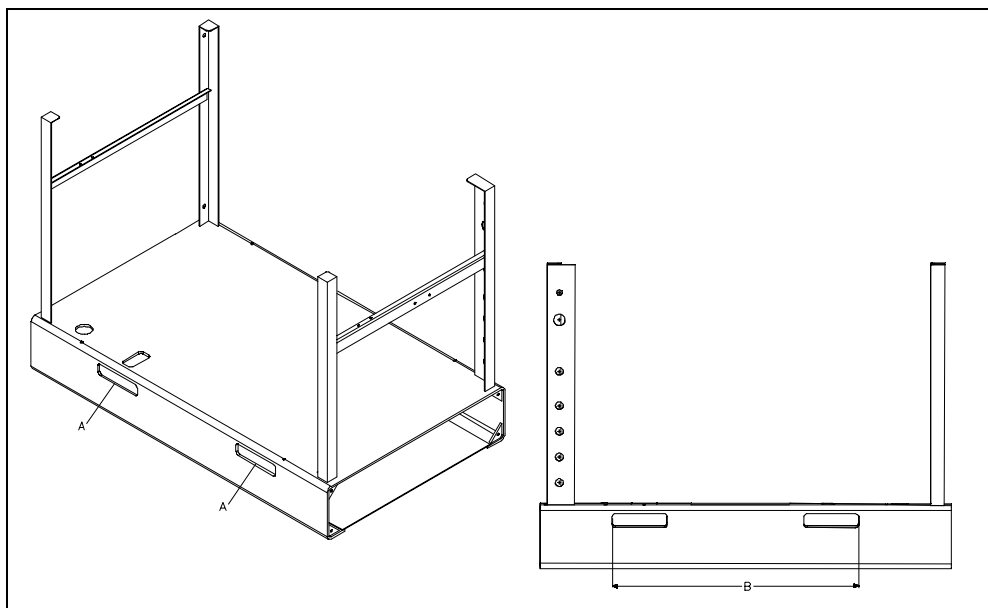


Table 2-2
Fork Pockets

A	Fork Pocket Dimensions	
	Height	2.0" (50.8 mm)
	Width	8.0" (203.0 mm)
	Length	36.0" (914.4 mm)
B	Distance Between Pockets	
		36.0" (914.4 mm)

If the machine will be installed in an overhead location, a forklift or crane can be used to position the pump. Heavy straps or chains, properly rated for the weight requirements, should be placed through each fork pocket, and wrapped around the sides of the machine so they meet on the top. The straps can then be attached to a crane or forklift to lift the machine.



The machine **must** be lifted from the bottom. **Do not** attempt to lift the machine from the intensifier.

2.4 Power Requirements

Power supplied to the pump and wiring for remote control must comply with local, regional and national electrical codes. Service voltage and ampacity must meet the requirements of the specific model. Voltage fluctuations in excess of +/- 10 percent of nominal voltage may damage the machine and void the warranty. Refer to Table 2-3, Ampacity and Power Voltage Requirements.

Table 2-3
Ampacity and Power Voltage Requirements

Power Voltage	Motor Horsepower	Full Load Amps	Circuit Breaker Amps
208/3/60	30	80	100
230/3/60	30	76	100
380/3/50	30	44	60
400/3/50	30	43	60
415/3/50	30	43	60
460/3/60	30	38	50
575/3/60	30	32	40
200/3/50-60	50	132	175
208/3/50-60	50	128	175
240/3/60	50	112	175
380/3/50	50	69	100
400/3/50	50	66	100
415/3/50	50	64	100
480/3/60	50	56	80
575/3/60	50	47	80

2.5 Service Connections

The intensifier requires two incoming water sources, cooling water and cutting water; two drain lines, cooling water and wastewater; a high pressure discharge line, and an air supply line. All piping must comply with local, regional and national codes.

All service connections are made on the rear bulkhead of the machine as shown in Figure 2-3, Service Connections. Table 2-4 lists the fittings required for each interface connection.

With the exception of the wastewater drain line, manual shutoff valves should be installed for all connections. To facilitate service, the valves should be located as close as practical to the interface connection.



Thoroughly purge all supply plumbing prior to connection to remove any residue that could contaminate the system.

Figure 2-3: Service Connections

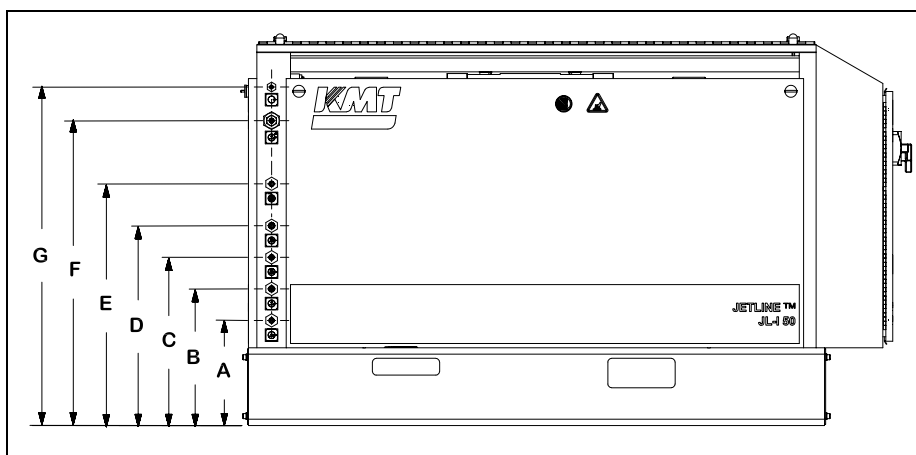


Table 2-4
Service Connections

		Connection	Height
A	Drain	1/2" BSPT	12.51" (318 mm)
B	Cutting Water In	1/2" BSPT	16.26" (413 mm)
C	Cooling Water In	1/2" BSPT	20.01" (508 mm)
D	Cooling Water Out	1/2" BSPT	23.76" (604 mm)
E	Contaminated Waste Drain	1/2" BSPT	28.76" (730 mm)
F	Cutting Water Out	9/16" HP	36.26" (921 mm)
G	Plant Air In	1/4" BSPT	40.26" (1,023 mm)

Cooling Water

Inlet cooling water flows through the oil-to-water heat exchanger in the hydraulic system to control heat buildup in the hydraulic oil. The cooling water is then discharged through the cooling water out port to either the drain or routed to a customer supplied water chiller.

Cooling water supply piping must be sized to meet the flow and pressure requirements of the equipment. If municipal or well water is used for cooling, ensure the supply flow and pressure meet the requirements in Section 11, Specifications.

If a facility-wide chilled water system is used for cooling, ensure there is a minimum of 35 psi (2.4 bar) pressure differential between the facility supply and discharge plumbing. Installation of an in-line pressure boosting pump may be necessary to provide adequate cooling flow. Dedicated chilled water systems should be sized according to pump horsepower as illustrated in Table 2-5, Chilled Water Systems.

Table 2-5
Chilled Water Systems
Cooling Requirements at Full Capacity

Horsepower	BTU/HR
30	13,400
50	22,000

Note: Coolant flow to the heat exchanger is regulated by the temperature of the contents in the hydraulic reservoir and will be shut off at times.

Cutting Water

Inlet cutting water is routed to the intensifier where it is pressurized and delivered to the cutting head. The cutting water supply must meet the minimum water quality standards outlined in Section 11, Specifications. Poor water quality will drastically shorten component life and void the warranty.

Cutting water supply piping must be sized to meet the flow and pressure requirements listed in Section 11. Only PVC, copper or rubber hose should be used between the cutting water source and the machine.

The inlet cutting water must be maintained at a minimum pressure of 35 psi (2.4 bar) at all times. If the facility water pressure is below, or can fall below 35 psi (2.4 bar), a water pressure booster pump is required.

NOTE

The machine will not start if inlet cutting water pressure is below 30 psi (2 bar).

Drain

Cutting water released through the safety dump valve when the emergency stop button is initiated is discharged from the drain port. The discharge is considered wastewater and must be piped to an appropriate location, i.e. a sewer line. The volume of water released will be minimal and does not require high pressure plumbing; however, piping must comply with local, regional and national codes.

Plant Air

The facility compressed air connection should provide clean, dry air regulated to 85 psi (5.9 bar). Air usage is minimal, normally less than 1 scf/m.

The following table provides specifications for each ISO air quality classification. KMT recommends adherence to Quality Class 4.

Table 2-6
ISO Air Quality Classifications

ISO Quality Class	Maximum Particle Size (microns)	Maximum Pressure Dew Point (water @ 100 psi)	Maximum Oil Content (Mg/m³)
1	0.1	-94° F (-60° C)	0.01
2	1	-40° F (-40° C)	0.1
3	5	-4° F (-20° C)	1
4	15	+38° F (+3° C)	5
5	40	+45° F (+7° C)	25
6	--	+50° F (+10° C)	--

Contaminated Waste Drain

Oil and water that can accumulate on the drip pans is disposed of through the contaminated waste drain on each pan. This oil and water mixture is considered contaminated and disposal must comply with local, regional and national codes. The volume of waste will be minimal and can be collected in a container of some appropriate type.

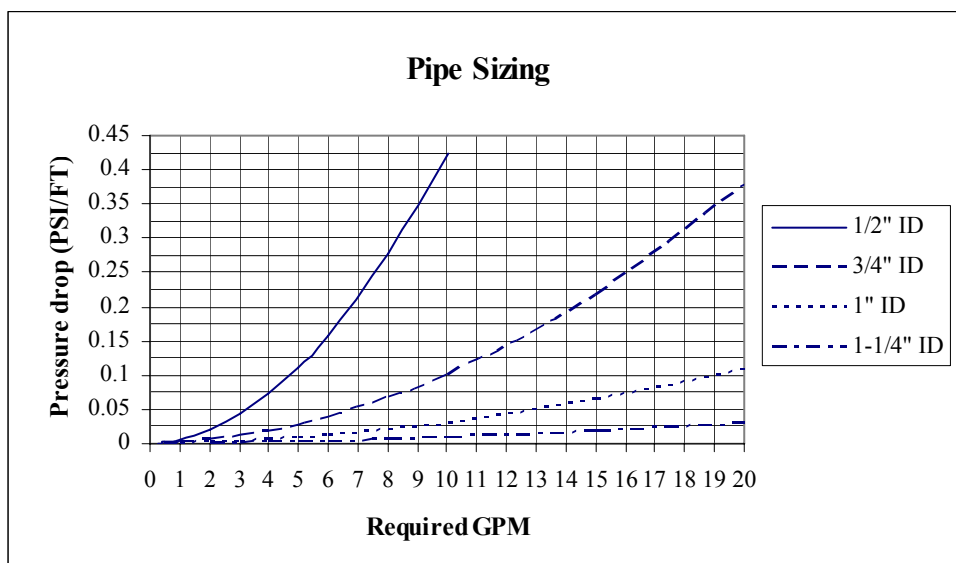
2.6 Flow Requirements

Figure 2-4, Pressure Drop Values, illustrates the pressure drop for four different pipe sizes. The graph can be used to calculate the minimum source water pressure.

1. Enter the graph at the required GPM and note the pressure drop figures for the different pipe sizes.
2. Multiply the pressure drop (PSI/FT) by the length in feet of each pipe size used from the water source to the intensifier. Add the values together for a total pressure drop value.
3. Add 30 to the total pressure drop to determine the minimum flowing, source water pressure required to provide adequate supply to the intensifier.

Cutting water and cooling water capacity should be calculated separately. Note that the cutting water requirements represent instantaneous, not average, demand.

Figure 2-4: Pressure Drop Values



2.7 High Pressure Piping

High pressure piping is used to transport high pressure cutting water from the machine to the cutting station. High pressure piping and fittings must be properly rated and sized. When transporting high pressure water over long distances, tubing and fittings with an outside diameter of 9/16-inch are recommended. The large tubing size reduces vibration, strain and motion; as well as reducing pressure drop and pulsation.



WARNING

High pressure tubing and fittings must be rated for 60,000 psi (4,136 bar). Failure to use properly rated components may result in component failure causing equipment damage, personal injury or death.

High pressure tubing lengths must be coned and threaded prior to installation. KMT Waterjet provides both hand and power tools for coning and threading high pressure tubing. Tool descriptions and part numbers are provided in Table 2-7.

Table 2-7
Coning and Threading Tools

	Part Number	
	Hand Tools	Power Tools
1/4" Coning Tool	05108832	05109897
3/8" Coning Tool	05108857	05109889
9/16" Coning Tool	05108840	05109871
1/4" Threading Tool	05108865	05122742
3/8" Threading Tool	05108873	05120258
9/16" Threading Tool	05108881	05122759



Table 2-7
Coning and Threading Tools

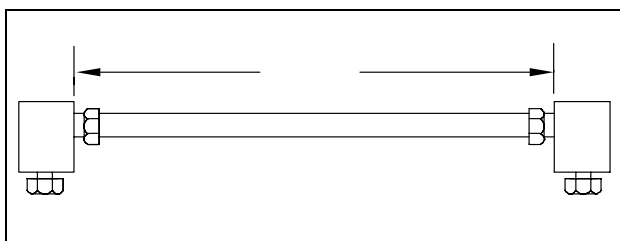
	Part Number
1/4" Tube Vise	05108782
3/8" Tube Vise	05108790
9/16" Tube Vise	05108774

Measurements and Dimensions

Tubing must be cut to the proper length, both ends of the tubing must then be coned, threaded and deburred.

To determine the tube length, measure the distance between the fittings, and add two times the engagement allowance shown in Table 2-8. Table 2-9 lists the required cone and thread dimensions illustrated in Figure 2-6.

Figure 2-5: Tube Length



$$\text{Tube Length} = \text{Length} + 2(\text{EA})$$

Table 2-8
Engagement Allowance (EA)

1/4" Tubing	0.49" (12.4 mm)
3/8" Tubing	0.68" (17.3 mm)
9/16" Tubing	0.86" (21.8 mm)

Figure 2-6: Cone and Thread Dimensions

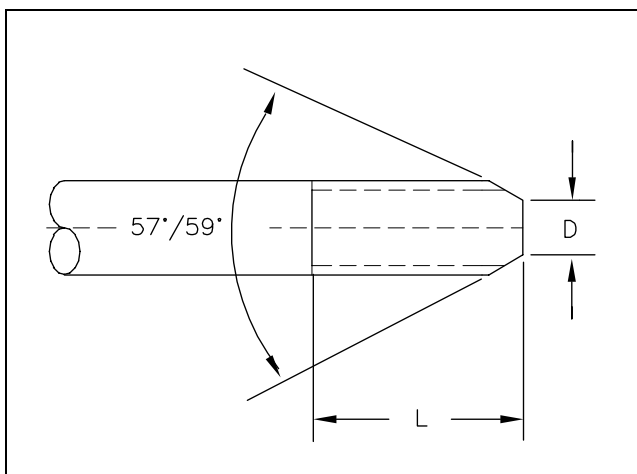
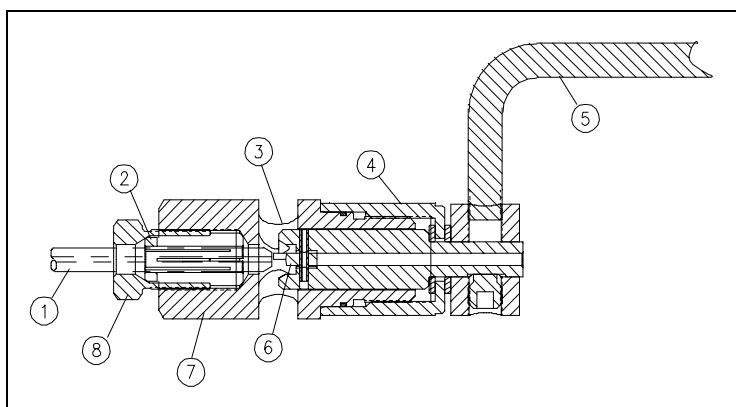


Table 2-9
Cone and Thread Dimensions

Tube OD	Tube ID	D (Maximum)	L (Maximum)	Thread UNF-LH
1/4" (6.35 mm)	0.083" (2.11 mm)	0.125" (3.2 mm)	0.562" (14.3 mm)	1/4" - 28
3/8" (9.52 mm)	0.125" (3.18 mm)	0.219" (5.6 mm)	0.750" (19.1 mm)	3/8" - 24
9/16" (14.29 mm)	0.188" (4.78 mm)	0.281" (7.1 mm)	0.938" (23.8 mm)	9/16" - 18

Hand Coning

Figure 2-7: Hand Coning Tool



- | | |
|-----------------|-------------|
| 1 Tubing | 5 Handle |
| 2 Collet | 6 Blade |
| 3 Access Window | 7 Body |
| 4 Feed Nut | 8 Gland Nut |

1. Place the body of the coning tool in a vise allowing adequate clearance for the rotation of the cutter handle. Position the tool so the cutter handle is elevated slightly so the lubricant will flow to the cutting blade.
2. Turn the feed nut counter-clockwise to retract the cutting blade past the access window.
3. Loosen the gland nut and insert the tubing through the collet. The end of the tubing should just make contact with the cutting blade. Loosely tighten the gland nut to slightly grip the tubing.
4. Turn the feed nut counter-clockwise 1/4 turn to retract the cutting blade away from the tubing, and tighten the gland nut with a wrench.
5. Apply a liberal amount of cutting oil to the exposed end of the tubing, the cutting blade and through the lubrication channel at the cutter handle.

Apply cutting oil frequently and liberally throughout the cutting operation. A medium weight cutting oil with high sulfur content is recommended.

6. Turn the feed nut clockwise until the cutting blade contact the end of the tubing.
7. In a smooth, continuous motion, turn the cutter handle in a clockwise direction. Simultaneously turn the feed nut in a clockwise direction to establish a constant feed. Do not remove too much material at once; the cutting blade should make light, uninterrupted cuts.

NOTE

Before interrupting the cut, back the cutter blade away from the tubing. Use compressed air or a small brush to remove the accumulation of chips from the blade and the tubing throughout the coning operation.

8. Continue the operation until the feed nut bottoms on the housing. Turn the cutter handle several more rotations to face-off the end of the cone.
9. Retract the cutter blade, loosen the gland nut and remove the tubing. Inspect the cone for surface finish and completeness.

NOTE

Clean the machining chips from the blade and from the collet before coning the next tube.

Power Coning

1. Secure the tubing in a tube vise. No more than the recommended length of tubing should extend beyond the face of the vice. See Table 2-10, Recommended Extension Length.
2. Mount the coning tool in a 3/8-inch or 1/2-inch, variable speed power drill. Apply cutting oil to the end of the tube and slide the coning tool on the tubing.
3. Apply steady pressure against the end of the tubing while the cone is being cut.

Apply cutting oil frequently and liberally throughout the cutting operation. A medium weight cutting oil with high sulfur content is recommended.

4. The tool will stop cutting when the tube angle and facing is complete.

NOTE

Clean the machining chips from the blade and body of the tool before coning the next tube.

Table 2-10
Recommended Extension Length

1/4" Tubing	1.25-1.50" (31.8-38.1 mm)
3/8" Tubing	1.25-1.50" (31.8-38.1 mm)
9/16" Tubing	1.75-2.00" (44.5-50.8 mm)

Hand Threading

1. Secure the coned tubing in a tube vise. No more than the recommended length of tubing should extend beyond the face of the vice. See Table 2-10, Recommended Extension Length.
2. Apply cutting oil to the end of the tube and slide the threading tool on the tubing.
3. Grip the handles of the tool firmly, apply steady pressure and turn the tool counter-clockwise. Approximately every half turn, reverse direction to break off and remove the chips.

Apply cutting oil frequently and liberally throughout the cutting operation. A medium weight cutting oil with high sulfur content is recommended.

4. Continue threading until the proper thread length is reached, see Table 2-9, Column L. Remove the tool from the end of the tubing.

NOTE

Clean the machining chips from the die and body of the tool before threading the next tube.

Power Threading

1. Secure the coned tubing in a tube vise. No more than the recommended length of tubing should extend beyond the face of the vice. See Table 2-10, Recommended Extension Length.
2. Mount the threading tool in a 3/8-inch or 1/2-inch, variable speed power drill. Apply cutting oil to the end of the tube and slide the threading tool on the tubing.
3. Make sure the drill is set to turn counter-clockwise. Apply steady pressure against the end of the tubing while the threads are being cut.

Apply cutting oil frequently and liberally throughout the cutting operation. A medium weight cutting oil with high sulfur content is recommended.

4. Continue threading until the proper thread length is reached. See Table 2-9, Column L. Reverse the direction of the drill and remove the threading tool.

NOTE

Clean the machining chips from the die and body of the tool before threading the next tube.

2.8 High Pressure Connections

When installing high pressure discharge piping it is essential that all burrs are carefully removed and the tubing sections purged with clean compressed air prior to assembly. Lightly spraying the inside of the tube with a carrier fluid, such as WD-40, before purging with air will help carry the burrs.

High pressure piping must be installed without torsional or bending stresses and proper supports and guides must be provided. Torsional stress will cause premature component failure.

Pure Goop anti-seize compound must be applied to the threads and contact surfaces of all stainless steel components prior to assembly. Failure to lubricate components with Pure Goop will result in galling, rendering the components useless.

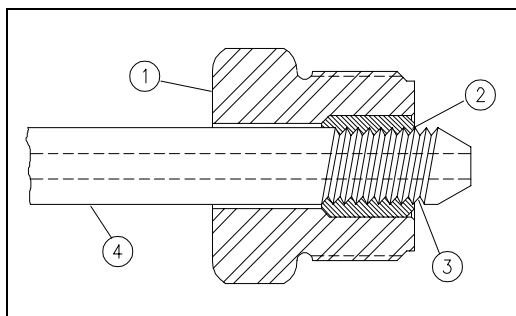
**CAUTION**

Do not use any other anti-seize compound. Apply Pure Goop **only to stainless steel** components.

Standard Connections

Standard connections are used for general applications where internal pressure is the only load on the tubing.

Figure 2-8: Standard High Pressure Connections



- | | |
|-------------|-------------------|
| 1 Gland Nut | 3 Exposed Threads |
| 2 Collar | 4 Tubing |

1. Deburr the tubing ID and thoroughly clean the tubing threads.
2. Slip the gland nut onto the tubing.

3. Apply Pure Goop to the threads on the tubing. Screw the collar onto the threaded end of the tubing leaving 1-1/2 to 2-1/2 threads exposed on the tubing between the collar and the coned tubing.
4. Apply Pure Goop to the male threads on the gland nut and insert the tubing into the connection. Engage the gland nut and tighten finger tight.
5. Tighten the gland nut to the torque specifications in Table 2-11.



WARNING

Proper piping supports and guides must be provided. End connections will not support the tubing load alone.

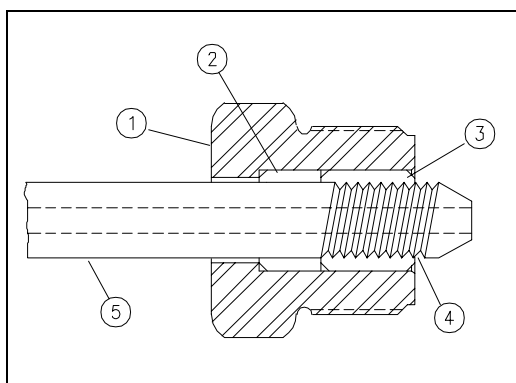
Table 2-11
Torque Specifications
High Pressure Connections

1/4" Tubing	25 ft-lb (34 Nm)
3/8" Tubing	50 ft-lb (68 Nm)
9/16" Tubing	110 ft-lb (149 Nm)

Anti-Vibration Connections

The bending stresses resulting from excessive vibration or shock on the threaded area of the tubing can cause premature failure at the back of the thread. When tubing will be subjected to vibration, rotation and movement, anti-vibration connections must be used. The anti-vibration collet gland transfers the stress to the unthreaded section of the tubing, and the gripping action of the collet strengthens the entire assembly.

Figure 2-9: Anti-Vibration Connections



- | | |
|-------------|-------------------|
| 1 Gland Nut | 4 Exposed Threads |
| 2 Collet | 5 Tubing |
| 3 Collar | |

1. Deburr the tubing ID and thoroughly clean the tubing threads.
2. Slip the gland nut and the collet onto the tubing.
3. Apply Pure Goop to the threads on the tubing. Screw the collar onto the threaded end of the tubing leaving 1-1/2 to 2-1/2 threads exposed on the tubing between the collar and the coned tubing.
4. Apply Pure Goop to the male threads on the gland nut and insert the tubing into the connection. Engage the gland nut and tighten finger tight.
5. Tighten the gland nut to the torque specifications in Table 2-11.

When a flexible whip is used to allow cutting nozzle movement, anti-vibration fittings and proper supports and guides must be provided to prevent failures from non-water related stresses. The whip will only flex in a single plane without being subjected to torsional stress. The use of high pressure swivels is strongly recommended.

2.9 Commissioning

When the machine has been positioned, all service connections installed, and the high pressure plumbing has been installed to the cutting area, the machine is ready to be commissioned.

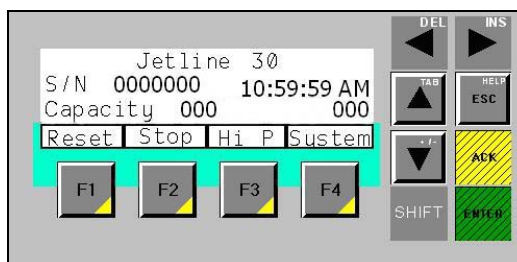
The following procedure is used for the initial startup and testing of the machine.

1. Check all areas in and around the pump for foreign objects and debris. Remove all tools, parts, etc. from the area.
2. Check the hydraulic fluid level. The hydraulic system is pre-filled prior to shipping. If the hydraulic fluid is low or empty due to leakage during transit, the system must be filled. Follow the instructions and specifications in Section 6, Recirculation System.
3. Open the shutoff valves on the service connections and check for leaks.
4. Check the connection between the customer supplied, main power disconnect and the disconnect/circuit breaker on the enclosure door. Verify the proper voltage supply. Close the enclosure door and turn the control power on.
5. To activate control power, pull the EMERGENCY STOP button out and press the RESET button. Refer to Section 4, Operation, for additional information regarding control panel functions.



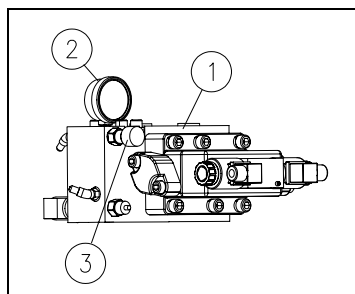
1 Emergency Stop 2 Reset Button

6. On the Run Screen, press the F3 button to select low pressure operation.



7. To avoid a sudden increase in pressure, it is necessary to adjust the high pressure setting. The high pressure adjustment is made at the high pressure control valve on the hydraulic manifold. Refer to Section 7, Hydraulic System, for additional information.

Loosen the locking nut on the high pressure control valve by turning counter-clockwise. Turn the high pressure control valve counter-clockwise, decreasing the pressure to the lowest setting.



- | | |
|----------------------------|-------------------------------|
| 1 Hydraulic Manifold | 3 High Pressure Control Valve |
| 2 Hydraulic Pressure Gauge | |

8. Check the motor rotation. Press the F1 button from the Run Screen to start the motor, and observe the pressure gauge on the hydraulic manifold. If the motor rotation is correct, pressure will begin to build in just a few seconds. If the rotation is not correct, the gauge will not move.

If the motor shaft is rotating in the wrong direction turn the control power off by pressing the EMERGENCY STOP button.

The electrical power phase must be reversed to any two motor leads. The leads can be reversed at the disconnect/circuit breaker on the enclosure door, or at the main power disconnect.



Do not allow the motor to run backward. Incorrect motor rotation will result in damage to the hydraulic pump.

9. Remove the cutting orifice and open the nozzle valve.

10. Activate the control power and press the F1 button on the Run Screen to start the motor. The dump valve will open for a short time to allow trapped air to bleed from the high pressure cylinders. Run the machine in low pressure for approximately five minutes with the orifice removed to purge the system.
11. Check for any leaks in the plumbing, or around the high pressure cylinders. If leaks are detected, stop the machine and correct any problems.
12. Observe the pressure gauge on the outlet manifold to ensure the discharge cutting water pressure is between 90-120 psi (6-8 bar). If not, the booster pump pressure must be adjusted. Refer to Section 5, Low Pressure Water System, for additional information.

Remove the acorn nut on the side of the booster pump and use a flat blade screwdriver to turn the adjustment screw. Turn the screw clockwise to increase the pressure or counter-clockwise to decrease the pressure.

13. Check the safety circuits by pushing the EMERGENCY STOP button in and verifying that the power goes off and high pressure water is drained from the system. If applicable, check all remote start and emergency stop functions.
14. Install a large, inexpensive orifice and start the machine.
15. Press the F3 button from the Run Screen to select high pressure operation. Increase the high pressure setting in gradual increments, checking for leaks at each interval. Continue increasing the pressure until the operating pressure is reached.

The high pressure setting is increased by turning the high pressure control valve on the hydraulic manifold clockwise.

NOTE

It is strongly recommended that the high pressure plumbing be purged under high pressure operating conditions, using a large, inexpensive orifice. Contamination can be released when the tubing expands under pressure. Early orifice failures could be experienced if the piping is not adequately purged.

2.10 Decommissioning

All local regulations must be adhered to when the intensifier is decommissioned and taken out of service for any reason.



SECTION 3

MAINTENANCE

3.1 Overview

The Jetline™ series has been designed to fail safely. Systems fail gradually; seals and connections can begin to leak slowly or suddenly through specially designed weep holes. Water or oil dripping from a weep hole indicates internal seals or valves are beginning to fail, a warning that maintenance will be required.

The comprehensive fault detection and troubleshooting logic built into the programmable logic controller (PLC) monitors crucial temperature and fluid levels. Warning and shutdown sensors guard against potential injury and equipment damage.

3.2 Maintenance

The waterjet system has been designed for ease of maintenance and long, reliable operation. In order to keep the equipment in optimum operating condition, routine and preventive maintenance is essential. Detailed maintenance procedures for specific systems are provided in subsequent sections of this manual.

Daily Inspection

The following inspection procedures should be performed each day. If problems are detected, they should be remedied before placing the machine in service.

- Prior to startup, inspect the area around the machine, the high pressure piping and connections for indications of leaks.
 - Make sure there is no maintenance work in process.
 - Check the hydraulic oil level.
- As the machine is started and water pressure increases, listen for unusual sounds.
 - Check for water or oil leakage.
 - Check the condition of the hydraulic oil filter
 - Check the condition of the low pressure water filter.

Periodic Maintenance

A number of factors can contribute to component failure; poor water quality, operating conditions, or improper maintenance procedures. Maintaining a service log can be a useful method of tracking component life and maintenance trends. Analyzing service intervals will assist in preparing a preventive maintenance schedule tailored to your specific application and production requirements. Periodic maintenance, at regularly scheduled intervals, will minimize unscheduled downtime and premature component failure.

Improper assembly can lead to the premature failure of components. Maintenance procedures must be followed carefully; components must be properly cleaned prior to assembly and tightened to the correct torque specifications.

- Maintain a clean, dust and dirt free work area for maintenance.
- Use only clean, dry air and clean, filtered solvent when flushing parts.
- Use lint free cloths for cleaning.
- Use extreme care when aligning close tolerance parts for assembly. Do not force the parts together. If parts bind during assembly, they must be disassembled and re-aligned.
- Use only original KMT Waterjet replacement parts for consistent performance and reliability; and to protect equipment warranty.

To avoid unsafe conditions and the risk of equipment damage, operating personnel and service technicians must carefully read and follow the procedures in this manual.

High Pressure System Maintenance

All high pressure service components are readily accessible, and can be removed from the unit easily for maintenance and service.

- High pressure fittings, valves and tubing must be rated for 60,000 psi (4,137 bar). Failure to use properly rated components may result in component failure, equipment damage and personal injury.
- Do not over-torque fittings to stop leakage.
- Ensure all components are clean, free of burrs, metal particles, dirt and dust prior to assembly.

After servicing high pressure components the high pressure water system must be thoroughly flushed to remove any debris or contaminants.

1. Operate the intensifier for a short period with the nozzle valve open and the orifice removed.
2. Turn the intensifier off and install an orifice.
3. Turn the machine on and increase the operating pressure in gradual increments. Check all high pressure connections for leaks.

Many components are lubricated prior to assembly. Table 3-1 lists the recommended lubricants and their applications. Substitutions are not recommended.

Table 3-1
Lubrication Specifications

Description	Application	Part Number
Pure Goop, 1 ounce	Stainless steel threads and metal-to-metal joints	10084440
FML-2 Grease, 14-1/2 ounce	O-rings, backup rings, bearing rings, seal components	10087385
JL-M Grease, 16 ounce	Non-stainless steel threads	49832199

3.3 Maintenance Precautions

Make sure all safety devices are operational. Each device should be checked on a specified schedule. If the device does not function, it must be replaced before operating the machine.

Check the EMERGENCY STOP button. The normal operating position is pulled out. Turn the power on and activate the emergency stop button by pushing it in to verify the power goes off and the safety dump valve opens to bleed the high pressure from the system.

Before performing any maintenance on the equipment, take the system out of service and make sure the controls are properly locked and marked. Never perform any maintenance on the equipment without making sure the main control power is locked out in the OFF position.

- **Never service or maintain the equipment while it is operating.**
- All high pressure leaks must be repaired immediately. Press the EMERGENCY STOP button to turn the control power off and bleed off the high pressure water from the intensifier **before** performing maintenance.
- Never service or maintain any high pressure component, or loosen any high pressure fitting when it is pressurized. Press the EMERGENCY STOP button to turn the control power off and bleed off the high pressure water from the intensifier before servicing.
- If leakage occurs at a sealing surface, high pressure water is released through weep holes. If a pressurized fitting is loosened, a jet of high pressure water will exit the nearest weep hole with **possible hazardous results**.

3.4 Tool Kit

Table 3-2 provides a list of the spare parts and maintenance tools included in standard tool kit for Jetline series pumps. Components can also be ordered individually.

Table 3-2
Tool Kit

Part Number	Description	Installation Tool Kit 20471547
10087385	FML-2 Grease, 14-1/2 ounce	1
10079986	Strap Wrench	1
20470475	Seal Installation Tools, Pneumatic Valve	1
72113886	Cartridge Removal Tool	1
10084440	Pure Goop, 1 ounce	3
10149052	Glass Pane, 8.0 x 8.0 x .25	1
10149045	Emery Cloth, 600 Grit	6
05066139	Cylinder Wrench	1
10148674	HP Seal Installation Tool	1
10149029	Emery Cloth, 320 Grit	2
10149037	Emery Cloth, 400 Grit	4
10081370	Spanner Wrench, .25	1
10127884	Spanner Wrench, .38	1
20487868	Threadlocker 242 Adhesive, .50 milliliter	1
20494983	Threadlocker Primer, 1-3/4 ounce	1
05103957	Hex Driver	1
20484488	Vee Block	1



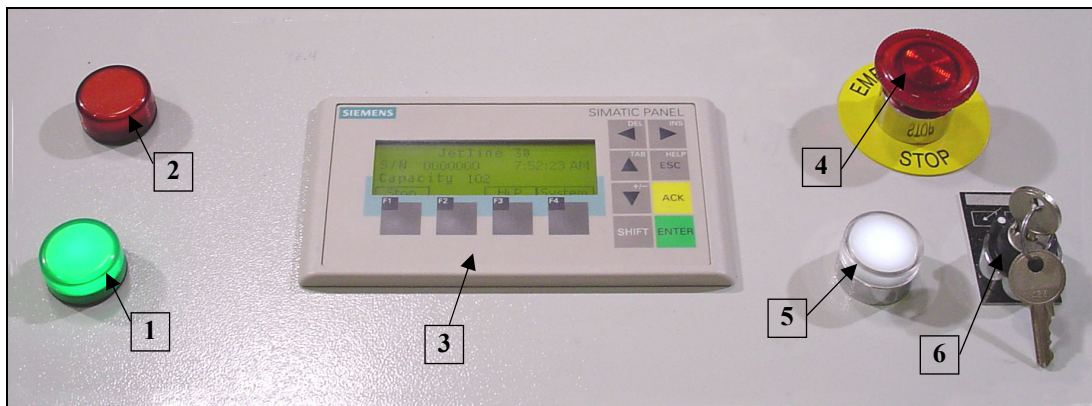
SECTION 4

OPERATION

4.1 Overview

The Jetline™ Series utilizes a programmable logic controller (PLC) to provide fault detection and troubleshooting logic. The operator functions and warnings offer a comprehensive view of impending and shutdown faults. The operator interface is through a function-button control panel.

Figure 4-1: Control Panel



- | | |
|--|--|
| 1 Green Light flashes at startup and remains on during operation | 4 Emergency Stop |
| 2 Red Light flashes to signal alarm condition | 5 Reset Button |
| 3 Function Button Control Panel | 6 Keyed switch transfers control to a remote panel |

4.2 Startup Sequence

The startup sequence varies depending on the previous stop condition.

Startup after Motor Stop

After a normal motor stop control power remains on, and the safety dump valve opens to release high pressure in the system. Press the F1 button on the Run Screen to initiate normal operation. The pump is held in low pressure for 20 seconds, it then goes to high pressure or remains in low pressure, depending on the previous pressure setting.

Startup after Emergency Stop









After an emergency stop control power is turned off, and the safety dump valve opens to release high pressure in the system. The dump valve will close three seconds after the intensifier begins to stroke.

Pull the E-STOP button out and push the RESET button to activate control power. Press the F1 button on the Run Screen to start the motor. The machine will be held in low pressure for 20 seconds to allow trapped air to bleed from the high pressure cylinders. It then goes to high pressure or remains in low pressure, depending on the previous pressure setting.

4.3 Keypad and Screen Functions

The keypad allows you to navigate and select functions on the screen, return to a previous screen and acknowledge alarms.

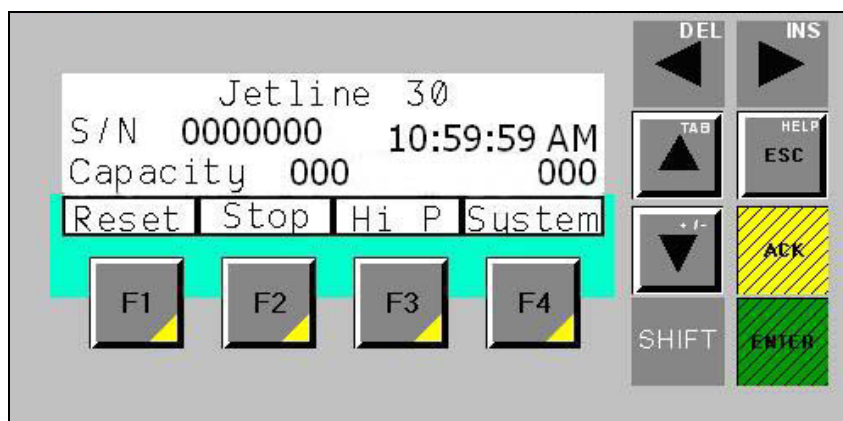
Table 4-1
Keypad Functions

	Function	Comments
	  	Use the arrows to highlight the desired function on the screen.
		When a fault condition occurs an alarm message will appear over the screen and a small triangle will flash in the corner of the screen. Pressing ESC will clear the message, allowing you to navigate the screen, but it will not clear the fault.
		Press ESC twice to return to the previous screen.
		To clear a fault, press the ▲ arrow to highlight the flashing triangle and press ENTER to display the alarm message. Press the ACK button to acknowledge the fault.
		Press ENTER to initiate a function.
		Icon displays above the F1 button on the System, Information, Settings and Maintenance Screens. Press F1 on these screens to return to the Run Screen.

4.4 Run Screen

The Run Screen is the only screen where the pump can be started to create pressure, and a normal motor stop can be performed.

Figure 4-2: Run Screen



On the Run Screen, the state of the function buttons F1, F2, F3 and F4 changes according to the current status of the pump. The available function at any given time is displayed above each button. For example, if the pump has been shut down the inlet water solenoid valve will be closed and the F1 button display will be RESET as illustrated above. Pressing the F1 button will reset and open the valve, and the display will change to START. Pressing the F1 button at this point will start the pump.

The following functions are performed from the Run Screen:

- Press the F1 button to reset the inlet water solenoid valve, start the pump to create pressure, or stop the pump. After the pump is stopped, there is a five-second delay before startup.

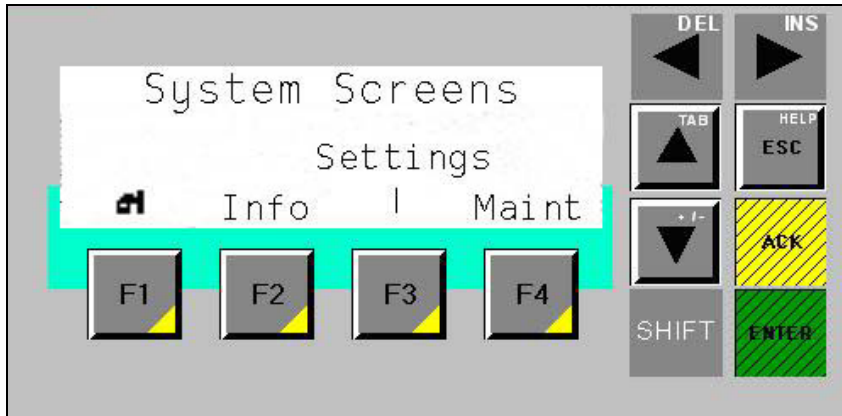
The inlet water solenoid valve is automatically closed five minutes after the pump shuts down. Press the F1 button to reset and open the valve.

- Press the F2 button to start the pump in recirculation mode. The pump will recirculate for 10 minutes before the function shuts off. Recirculation can be manually stopped by pressing the F2 button. Recirculation time is indicated in the lower right-hand corner of the screen.
- Press the F3 button to select low or high pressure operation.
- Press the F4 button to display the System Screen.

4.5 System Screen

Pressing the F4 button on the Run Screen will display the System Screen options: information, settings and maintenance.

Figure 4-3: System Screens

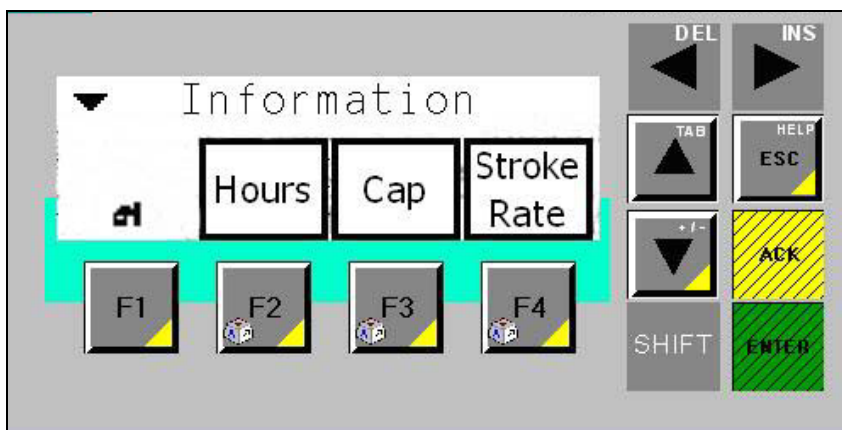


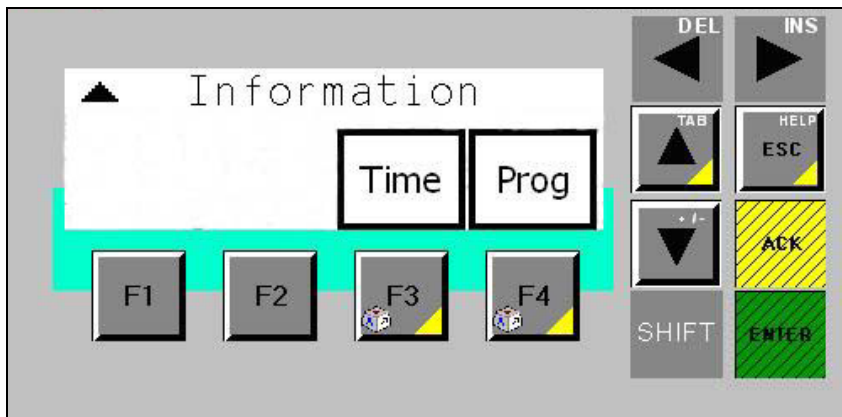
- Press F1 to return to the Run Screen
- Press F2 to display the Information Screen
- Press F3 to display the Settings Screen
- Press F4 to display the Maintenance Screen

4.6 Information Screen

Information screens display equipment and operating information. No functions are preformed from these screens. The ▲ or ▼ arrow in the top, left-hand corner of the screen indicates additional options. Use the ▲ or ▼ arrow on the keypad to view all information options.

Figure 4-4: Information Screen

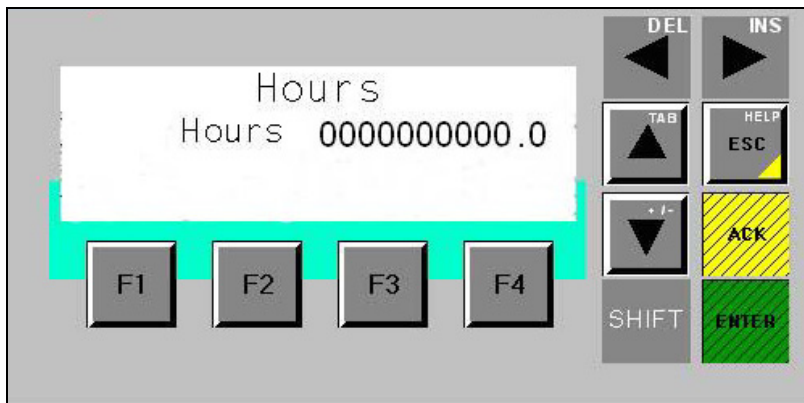




Hours Screen

The Hours Screen displays the total operating hours.

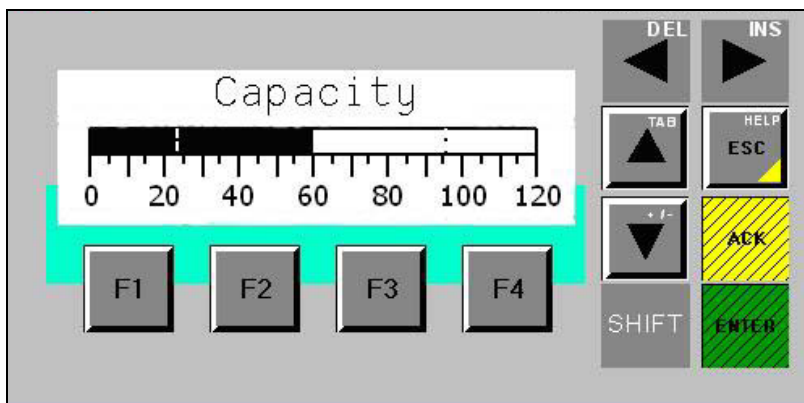
Figure 4-5: Hours Screen



Capacity Screen

The Capacity Screen displays the pump capacity as a percentage based on stroke rate.

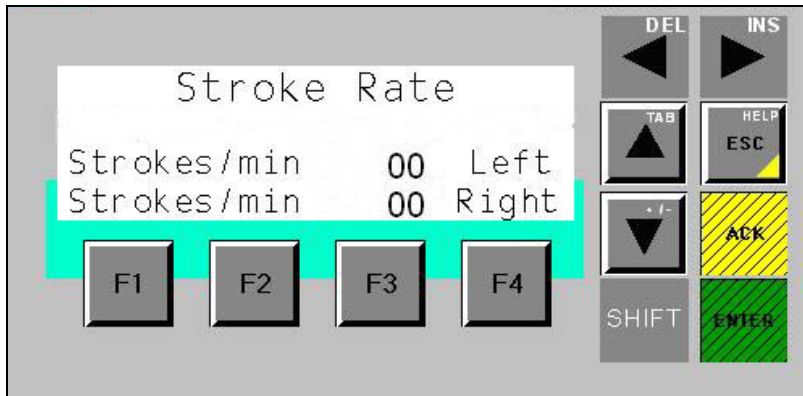
Figure 4-6: Capacity Screen



Stroke Rate Screen

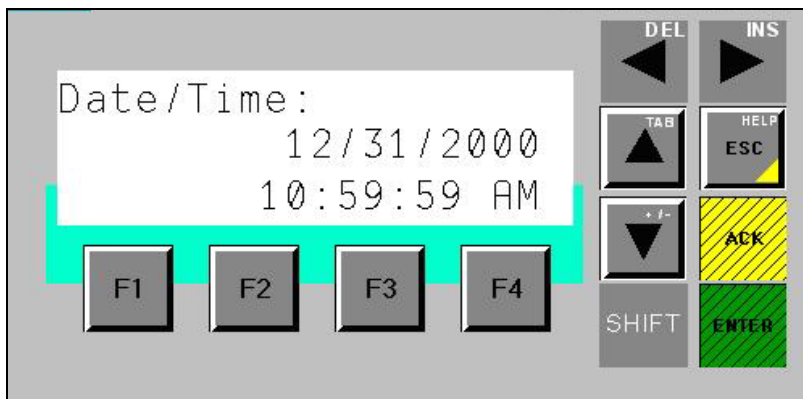
The Stroke Rate Screen displays the actual stroke rate as strokes/minute on both the left and right side of the intensifier.

Figure 4-7: Stroke Rate Screen

**Date/Time Screen**

The Date/Time Screen displays the date and time.

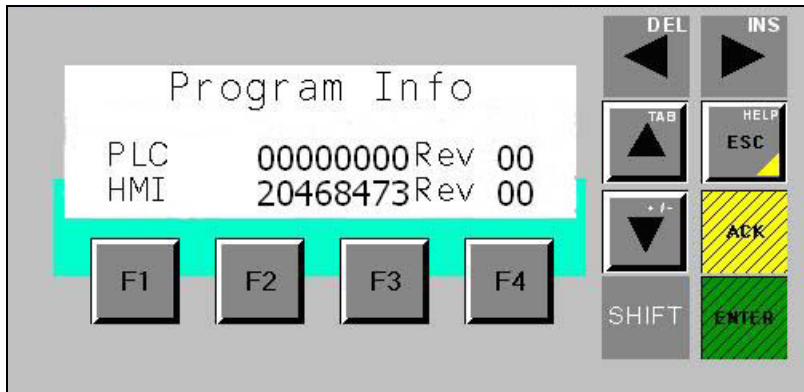
Figure 4-8: Date/Time Screen



Program Information Screen

The Program Information Screen displays the PLC and HMI program numbers and revision levels.

Figure 4-9: Program Information Screen

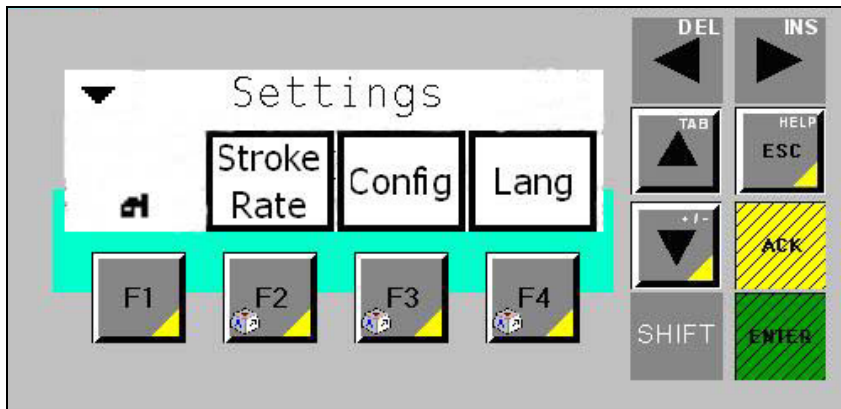


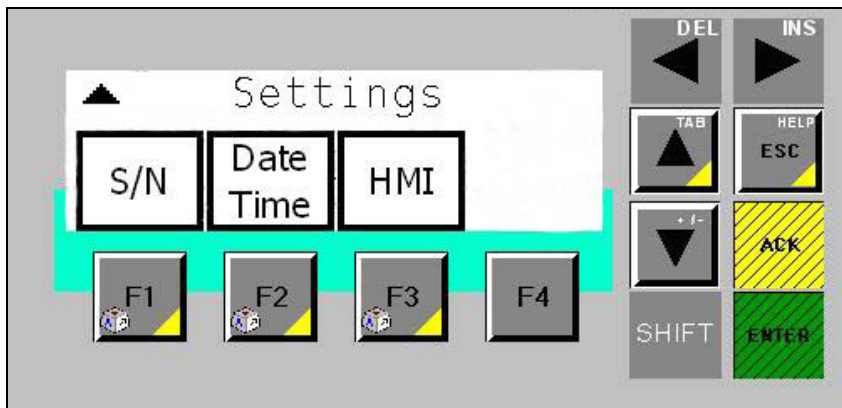
4.7 Settings Screen

Operating parameters and equipment options are established on the settings screens. The ▲ or ▼ arrow in the top, left-hand corner of the screen indicates additional options. Use the ▲ or ▼ arrow on the keypad to view all information options.

All settings screens are password protected and some screens are not accessible at the customer level. Customer available screens require a login and password to access.

Figure 4-10: Settings Screen



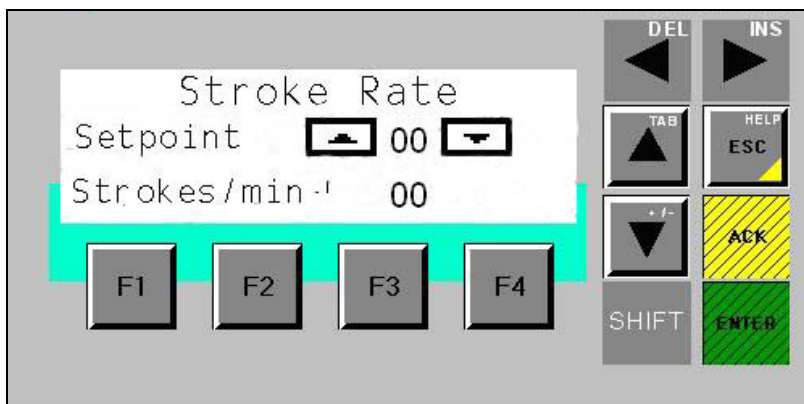


Stroke Rate Screen

The overstroke setpoint is increased or decreased from the Stroke Rate Screen. Stroke rate should be set slightly higher than the desired operating rate to shutdown the machine quickly in the event of an overstroke condition. The upper limit stroke rate is preset according to the horsepower rating of the machine. The JL-1 30 is preset at 37 strokes per minute and the JL-1 50 is preset at 60 strokes per minute.

Before setting the stroke rate, monitor the actual strokes/minute during normal operation. The overstroke setpoint should then be set 20% above that rate.

Figure 4-11: Stroke Rate Screen



To increase or decrease the stroke rate, use the arrows on the keypad to highlight the desired ▲ or ▼ button on the screen. Continue to press ENTER until the desired stroke rate is displayed.

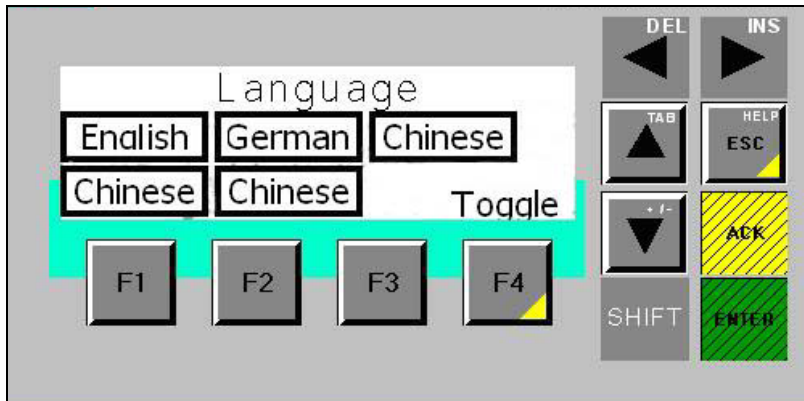
Configuration Screen

The configuration screen is used at initial startup to set the horsepower and equipment parameters for the specific pump. The Configuration Screen is not accessible at the customer level.

Language Screen

The Language Screen lists the available display languages. Use the arrows on the keypad to highlight the desired language and press ENTER to select. Or Press F4 to toggle through the languages.

Figure 4-12: Language Screen



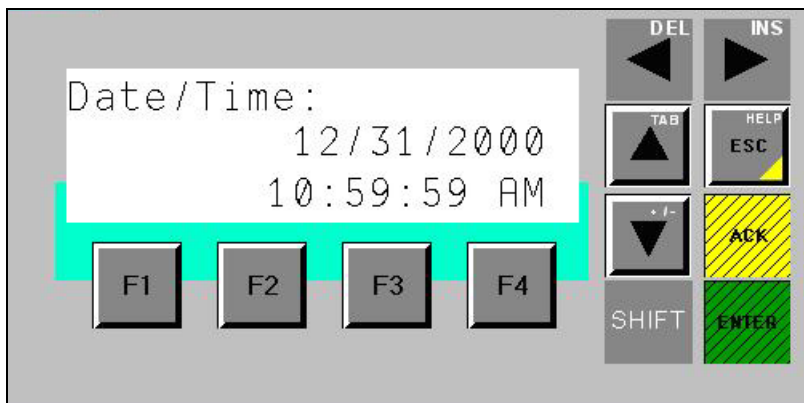
Serial Number Screen

The Serial Number Screen is password protected and used to record the serial number for the specific pump. The Serial Number Screen is not accessible at the customer level.

Date/Time Screen

The date and time are changed from the Date/Time Screen. Use the arrows on the keypad to highlight the value to be changed, month, day, year, etc. Press ENTER until the desired value is displayed.

Figure 4-13: Date/Time Screen



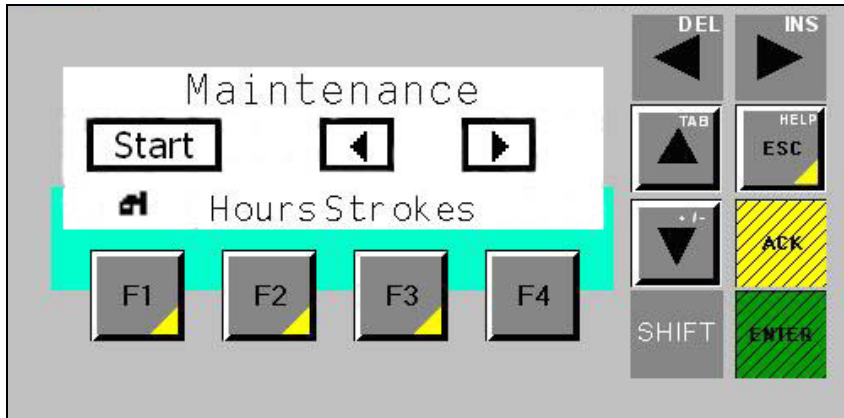
HMI Screen

The HMI Screen is used to load a new operating program and is not accessible at the customer level.

4.8 Maintenance Screen

The Maintenance Screen is used to facilitate maintenance procedures and reset maintenance hours and strokes. When started from the Maintenance Screen, the pump starts in maintenance mode.

Figure 4-14: Maintenance Screen



- Use the arrows on the keypad to highlight the START button and press ENTER to start the pump in maintenance mode.
- Use the arrows on the keypad to highlight the left or right arrow on the screen and press ENTER to initiate.

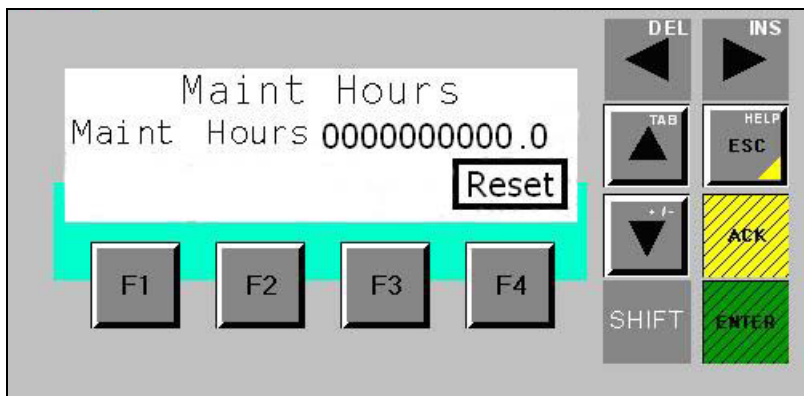
The left arrow on the screen will extend the plunger to the left, allowing full exposure to the left plunger when the unit is disassembled. The right arrow on the screen will extend the plunger to the right, allowing full exposure to the right plunger when the unit is disassembled.

- Use the arrows on the keypad to highlight the STOP button and press ENTER to stop the pump.

Maintenance Hours Screen

Use the arrows on the keypad to highlight the RESET button and press ENTER to reset the maintenance hours.

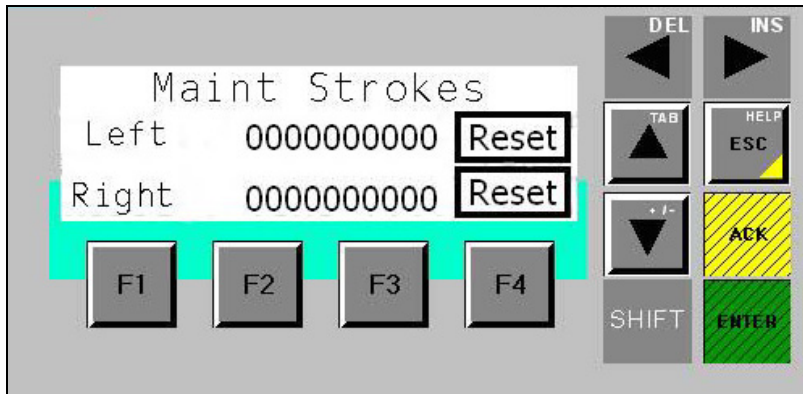
Figure 4-15: Maintenance Hours Screen



Maintenance Strokes Screen

Use the arrows on the keypad to highlight the left or right RESET button and press ENTER to reset the maintenance strokes.

Figure 4-16: Maintenance Strokes Screen



4.9 Alarms

When a fault condition occurs an alarm message appears over the screen and a small triangle flashes in the corner of the screen. Pressing SHIFT and ESC will initiate the help function. Additional information regarding the type of alarm and possible remedies will display.

Pressing ESC will clear the message, allowing you to navigate the screen, but it will not clear the fault. To clear a fault, press the ▲ arrow on the keypad to highlight the flashing triangle and press ENTER to display the alarm message. Press the ACK button to acknowledge the fault.

**Table 4-2
Alarms**

Alarm	Indication	Possible Remedies
Left Overstroke Shutdown	A left overstroke condition has occurred.	Check left high pressure seal
		Check right discharge check valve
		Check left inlet check valve
Low Booster Pressure	Discharge pressure from the booster pump is low, below 60 psi (4 bar).	Check the inlet water pressure
		Check the filter element and replace if dirty
		Adjust or replace the booster pump
Low Inlet Water Pressure	Inlet cutting water pressure is low, below 30 psi (2 bar).	Check pipe sizing for inlet cutting water for pressure and flow
Motor Feedback Failure	Start relay did not close at start-up or opened due to a fault	Check motor starter relay

Table 4-2
Alarms

Alarm	Indication	Possible Remedies
Motor Overload	PLC monitors the motor overload relay and displays a message when the overloads trip. Overloads are set on automatic reset.	Check incoming voltage
		Check overload setting
		Check the motor amperage
Oil Level Low	Low oil level.	Check sight level gauge
		Check for hydraulic leaks
		Check the oil level switch
Oil Temperature High	High oil temperature.	Check cooling water source
		Check water modulating valve
		Check the oil temperature switch
Right Overstroke Shutdown	A right overstroke condition has occurred.	Check right high pressure seal
		Check left discharge check valve
		Check right inlet check valve
T/W Overstroke Shutdown	An intensifier overstroke condition has occurred.	Check plumbing for leaks
		Check high pressure orifice
		Check inlet water pressure
		Check the inlet and discharge check valves
		Check the incoming water pressure



SECTION 5

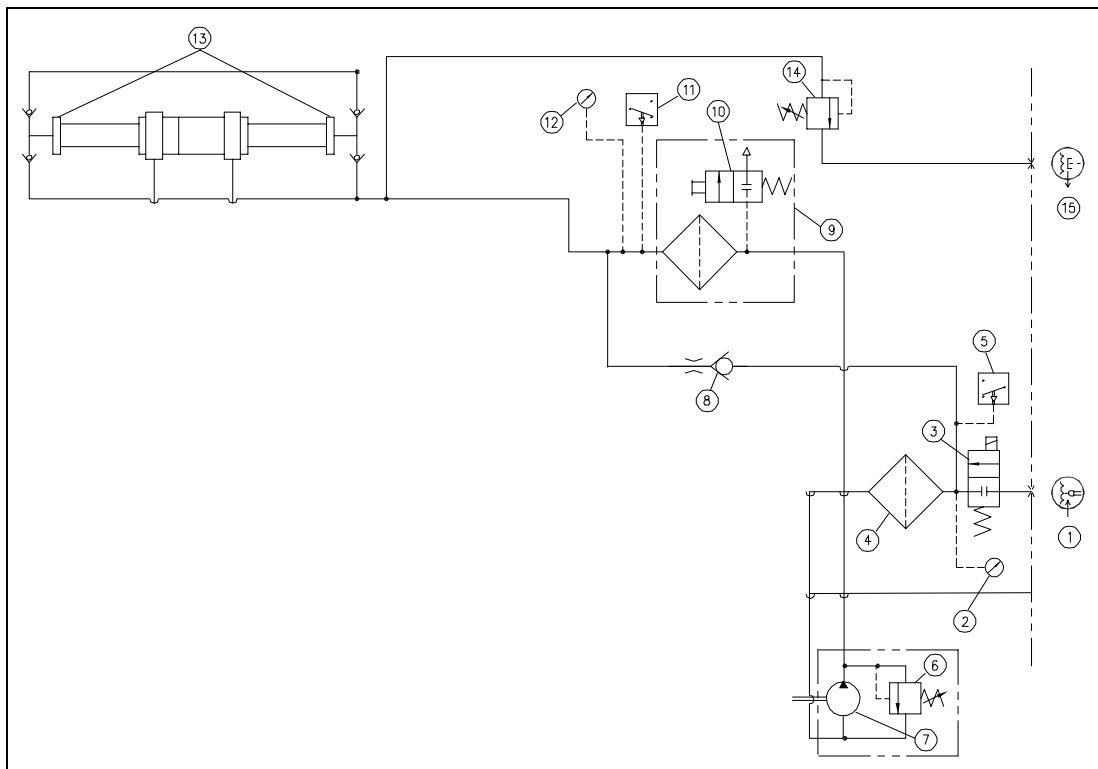
LOW PRESSURE WATER SYSTEM

5.1 Overview

The Jetline™ series utilizes two low pressure circuits: cutting water supply and cooling water supply. This section will discuss the cutting water supply circuit. See Section 6, Recirculation System, for a detailed explanation of the cooling water supply circuit.

The cutting water supply circuit supplies the intensifier with the required cutting water flow and pressure. System components include the inlet water solenoid valve, strainer, booster pump, and the low pressure filter assembly. Pressure switches, connected to the PLC, monitor out of tolerance conditions in the cutting water circuit and provide automatic shutdown protection.

Figure 5-1: Cutting Water Supply Circuit



- | | | |
|------------------------------|--------------------|---------------------------|
| 1 Cutting Water In | 6 Relief Valve | 11 60 psi Pressure Switch |
| 2 Pressure Gauge | 7 Booster Pump | 12 Pressure Gauge |
| 3 Inlet Water Solenoid Valve | 8 Check Valve | 13 Sealing Head |
| 4 Strainer | 9 Filter Assembly | 14 Relief Valve |
| 5 30 psi Pressure Switch | 10 Air Bleed Valve | 15 Drain |

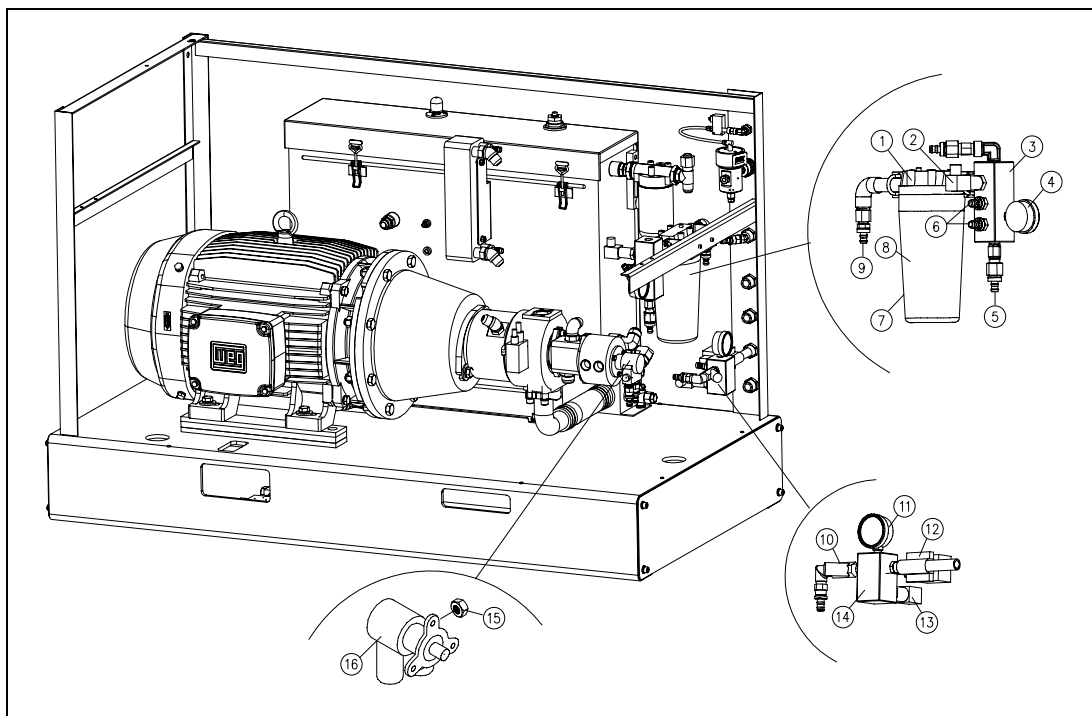
5.2 Cutting Water Supply

The quality of the inlet cutting water supply is one of the most important factors affecting component life and performance. Impurities in the water create grinding and corrosive effects on all components. See Section 11, Specifications, for details regarding water quality standards.

5.3 Operation

Cutting water is introduced through the 1/2-inch BSPT connection on the rear bulkhead of the machine. Inlet cutting water pressure should be a minimum of 35 psi (2.4 bar) flowing, and can be monitored from the supply gauge mounted on the inlet manifold.

Figure 5-2: Low Pressure Water System



- | | | |
|--------------------------|-------------------------------|---------------------------|
| 1 Filter Head | 7 Filter Housing | 13 30 psi Pressure Switch |
| 2 60 psi Pressure Switch | 8 Filter Element | 14 Inlet Manifold |
| 3 Outlet Manifold | 9 In from Booster Pump | 15 Relief Valve Acorn Nut |
| 4 Pressure Gauge | 10 Strainer | 16 Booster Pump |
| 5 Out to Drain | 11 Pressure Gauge | |
| 6 Out to Intensifier | 12 Inlet Water Solenoid Valve | |

Cutting water enters through the normally closed, inlet water solenoid valve. When the control power is turned on, the solenoid valve opens and allows water to flow through the valve. The inlet water is monitored by a 30 psi pressure switch mounted on the inlet manifold. If the pressure drops below 30 psi (2 bar) the switch activates an automatic shutdown circuit in the PLC and the machine will not start.

NOTE

The machine will not start if inlet cutting water pressure is below 30 psi (2 bar).

If a shutdown occurs due to an overstroke condition, the inlet solenoid valve automatically closes to prevent water waste due to an external leak.

Cutting water then passes through a strainer to remove debris before the water enters the booster pump. The booster pump increases the pressure to the relief valve setting, up to a maximum of 120 psi (8 bar) to ensure proper supply to the intensifier assembly.

Pressurized water passes through the filter assembly where debris is removed to prevent contaminants from damaging the check valves and seals in the intensifier. The filter assembly consists of a filter head, housing and a filter element. A bleed valve on the top of the filter head is used to release pressure or air inside the housing.

As the water enters the outlet manifold, the pressure is monitored by a 60 psi pressure switch. An automatic shutdown will occur if the pressure is below 60 psi (4 bar).

If the booster pump pressure exceeds 125 psi (8.6 bar) a relief valve opens allowing water to exit through the 1/2-inch drain connection on the rear bulkhead. It is still possible to operate the machine; however, excess water will continue to be released through the drain.

Discharge pressure is displayed on the pressure gauge mounted on the outlet manifold. The gauge should read approximately 120 psi (8 bar) while the machine is idling. When it strokes, the pressure drop should be no greater than 30 psi (2 bar). The water pressure range should remain between 90-120 psi (6-8 bar) during operation.

NOTE

While the intensifier assembly reverses direction, the boosted pressure will fluctuate slightly above and below the normal setting.

A relief valve built into the filter assembly prevents excessive discharge pressure and typically operates when the machine is in a deadhead condition. The booster pump is factory set to deliver 120 psi (8 bar) with an inlet pressure of 58 psi (4 bar). The pump may require adjustment to satisfy system requirements. To reduce overheating during a deadhead condition, water is re-circulated through the orifice and check valve, and routed back through the strainer to the booster pump inlet.

From the outlet manifold, cutting water is routed to the inlet check valves in the sealing heads on each end of the intensifier.

5.4 Service and Maintenance Procedures

To ensure water quality and supply to the high pressure system, the filter element, strainer and booster pump will require routine servicing and maintenance. The procedures for servicing these components are detailed below.

NOTE

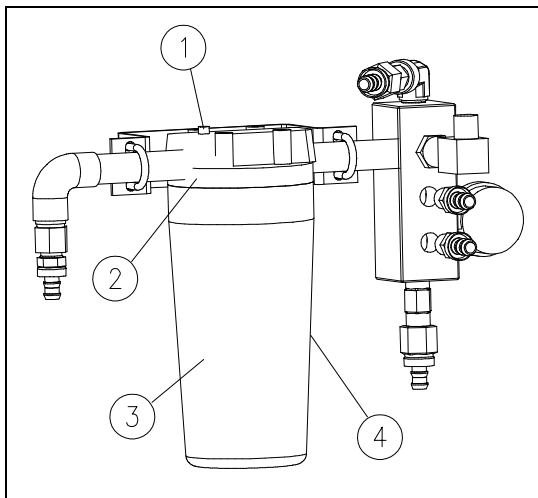
Refer to Section 12, Parts List for a complete listing of replacement parts and part numbers.

Filter Assembly and Strainer Maintenance

The life of the filter element is directly related to the quality of the inlet water. The condition of the filter element can be monitored by observing the pressure gauge on the outlet manifold. Document the pressure reading when the filter element is new. The element should be replaced when the pressure drops to 15 psi (1 bar) below the original value. When the filter element is replaced, the strainer should also be cleaned.

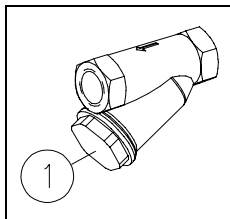
The following procedure is used to replace the filter element and clean the strainer.

Figure 5-3: Filter Element



- | | |
|---------------|------------------|
| 1 Bleed Valve | 3 Filter Element |
| 2 Filter Head | 4 Filter Housing |

1. Turn the cutting water supply off.
2. Press the red bleed valve on the filter head to release any pressure trapped inside the housing.
3. Use a filter wrench to unscrew the housing and remove the old element.
4. Install the new element. Apply FML-2 grease to the o-ring in the filter housing and use the filter wrench to replace the housing.

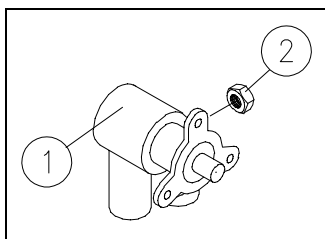
Figure 5-4: Strainer

1 Plug

5. Unscrew and remove the strainer plug and seal ring. Remove and clean the mesh liner.
6. Install the liner. Ensure the seal ring is properly positioned; replace the plug and hand-tighten.
7. Turn the cutting water supply on.
8. Press the red bleed valve to remove any air inside the filter housing.
9. Start the machine and verify satisfactory pressure readings.

Booster Pump Adjustment

If the discharge pressure from the booster pump stays below 90 psi (6 bar) while the intensifier is shifting, the relief valve on the booster pump should be adjusted.

Figure 5-5: Booster Pump

1 Booster Pump

2 Relief Valve Acorn Nut

1. Turn the cutting water supply on.
2. Start the machine and initiate normal, shifting operation.
3. Observe the discharge pressure from the booster pump. If the pressure stays below 90 psi (6 bar), continue with Step 4.
4. Stop the intensifier and remove the acorn nut on the side of the pump to access the adjustment screw. It is normal for water to leak out when the acorn nut is removed.
5. Use a flat screwdriver and turn the adjustment screw clockwise to increase the discharge pressure or counter-clockwise to decrease the pressure. Adjust the pressure to the highest desired pressure, within normal booster pump range.

**CAUTION**

If the adjustment screw is turned too far out (counter-clockwise) an internal spring and relief will fall down inside the pump. If this occurs, the pump must be removed and the parts must be reinstalled to avoid component damage.

6. Replace the acorn nut, resume normal operation and observe the booster discharge pressure. Peak pressure should be in the range of 90 to 120 psi (6 to 8 bar). If it is not, repeat the adjustment procedure.

SECTION 6

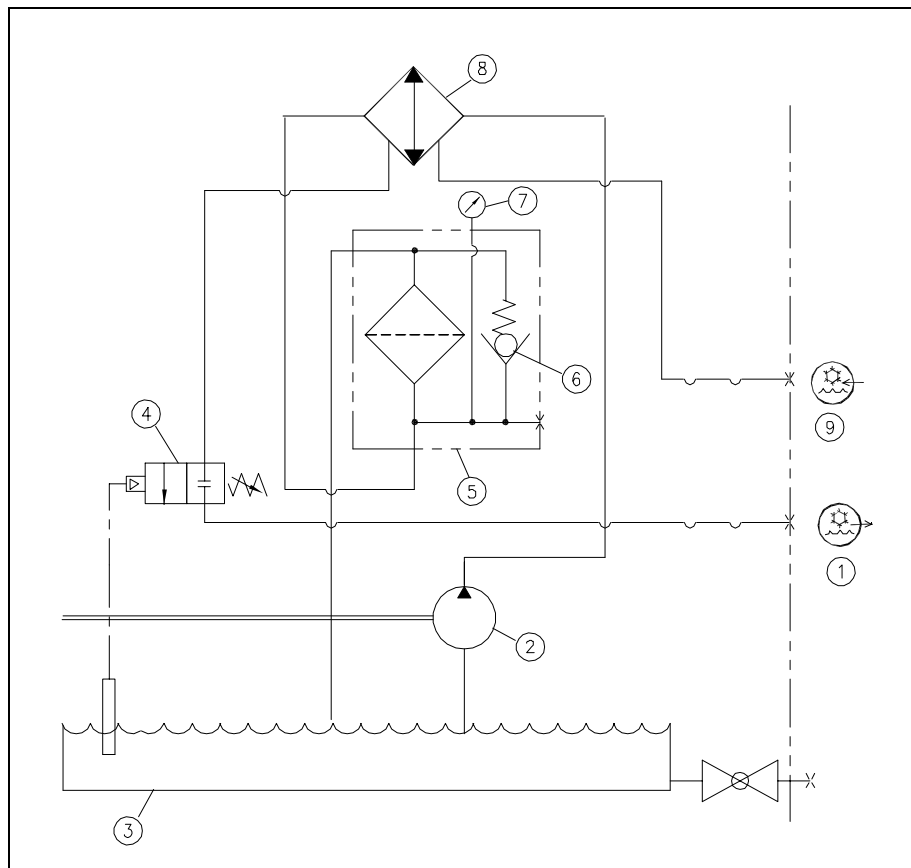
RECIRCULATION SYSTEM

6.1 Overview

The oil recirculation circuit is a cooling and filtration system that provides properly conditioned oil to the main hydraulic system. Hydraulic oil is maintained at the proper operating temperature and condition by continuous recirculation.

System components include the water modulating valve, recirculation pump, heat exchanger, oil filter assembly and the hydraulic oil reservoir. A temperature/low level switch, connected to the PLC, monitors temperature and oil level conditions in the hydraulic oil reservoir and provides automatic shutdown protection.

Figure 6-1: Oil Recirculation Circuit

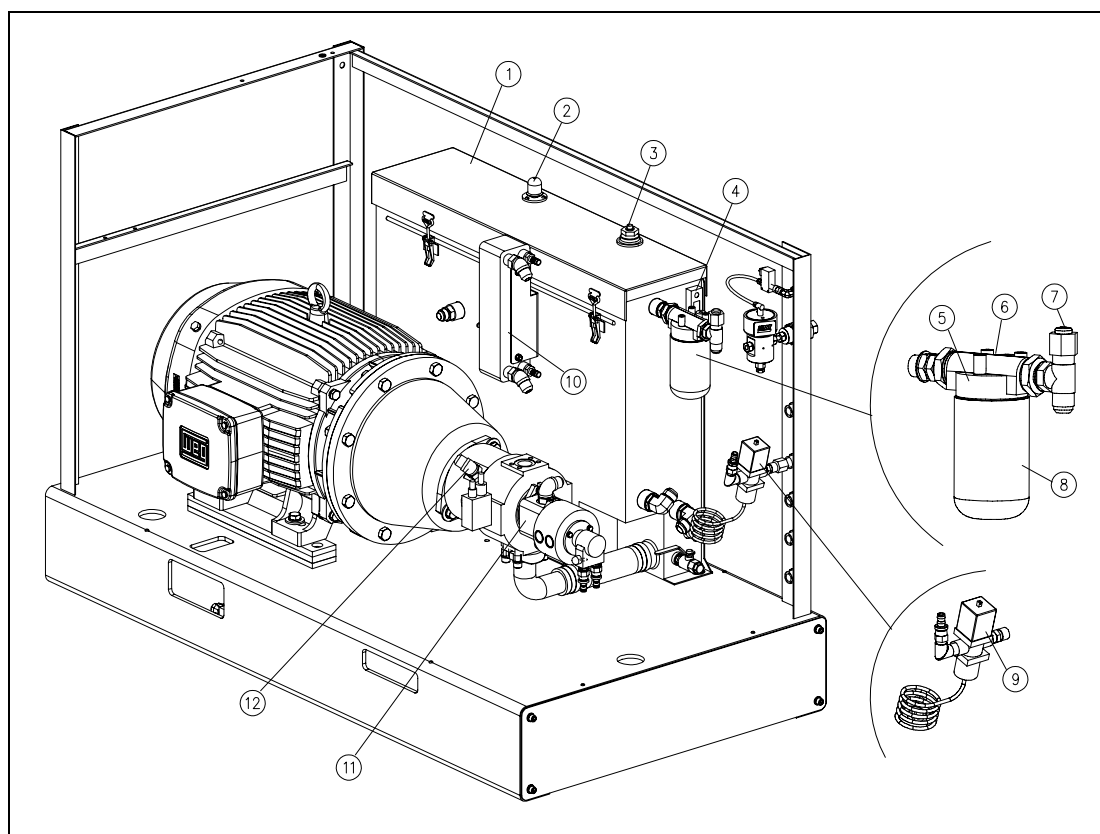


- | | | |
|---------------------------|--------------------------|--------------------|
| 1 Cooling Water Out | 4 Water Modulating Valve | 7 Pressure Gauge |
| 2 Recirculation Pump | 5 Oil Filter Assembly | 8 Heat Exchanger |
| 3 Hydraulic Oil Reservoir | 6 Bypass Relief Valve | 9 Cooling Water In |

6.2 Operation

Cooling water is introduced through the 1/2-inch BSPT connection on the rear bulkhead of the machine. A water modulating valve in the outlet line regulates the cooling flow through the heat exchanger. The valve is factory set, but may require adjustment to maintain the operating oil temperature at 115° F (46° C). Oil temperature can be visually monitored from a dual scale level/temperature sight gauge on the side of the hydraulic oil reservoir.

Figure 6-2: Recirculation System Components



- | | |
|---------------------------------|--------------------------|
| 1 Hydraulic Oil Reservoir | 7 Oil Fill Port |
| 2 Air Breather | 8 Filter Element |
| 3 Temperature/Low Level Switch | 9 Water Modulating Valve |
| 4 Level/Temperature Sight Gauge | 10 Heat Exchanger |
| 5 Filter Head | 11 Recirculation Pump |
| 6 Pressure Gauge | 12 Case Drain |

The recirculation pump pulls oil from the reservoir and sends it to the heat exchanger. The oil-to-water heat exchanger controls heat build-up in the hydraulic oil. The plate style design allows cooling water and oil to flow side by side through alternating plates.

The cooled oil then passes through the filter element and returns to the reservoir. The cooling water either is discharged to the drain on the rear bulkhead or is routed to a customer supplied water chiller.

The hydraulic oil filter assembly consists of the filter head with bypass relief valve, pressure gauge; filter element and the oil fill port. The filter element should be changed when the gauge reads 40 psi (2.8 bar) at normal operating temperature.

If the element is not replaced, and fills with debris, the bypass relief in the filter head will open to prevent over pressurization. The relief valve opens at 50 psi (3.4 bar). When the valve opens, the oil bypasses the filter and unfiltered oil is allowed to return to the reservoir.

The temperature/low level switch monitors the oil temperature and level in the reservoir. An automatic shutdown will occur if the operating oil temperature exceeds 145° F (63° C). An automatic shutdown will also occur if the oil level falls below 30 gal (114 L).

NOTE

To conserve water usage it is recommended that the cooling water be shut off at the end of the day. A sensor bulb from the modulating valve is submerged in the reservoir. Even when the control power is off, the valve will remain open, allowing water to flow until the oil is cooled.

6.3 Service and Maintenance Procedures

To ensure the supply of properly conditioned oil to the main hydraulic system, the components will require routine servicing and maintenance. The procedures for servicing these components are detailed below.

NOTE

Refer to Section 12, Parts List for a complete listing of replacement parts and part numbers.

Hydraulic Oil Maintenance

The hydraulic oil should be replaced after 3,000 hours or one year of service, whichever comes first. The oil should be replaced sooner if a fluid sample indicates contamination that cannot be rectified by filtering.

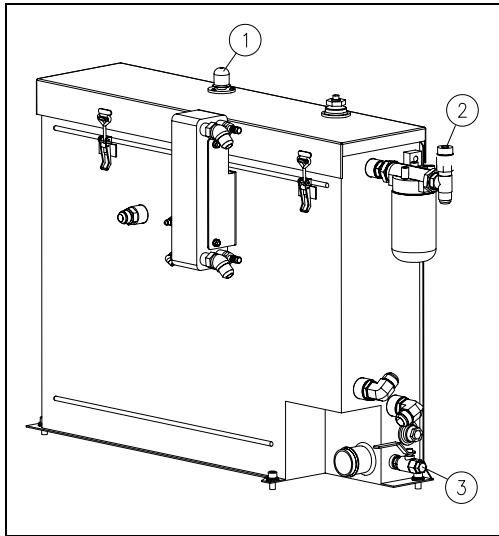
An air breather and filter are located on the top of the reservoir. The air breather prevents dirt from being sucked into the reservoir when the oil level drops, and allows air to escape when the level rises. The air breather must not be used as a fill point. Oil **must only** be replaced at the fill port on the filter head.



CAUTION

Do not attempt to fill the reservoir from the air breather. The oil will not be filtered and will not conform to the cleanliness requirements of the system.

Figure 6-3: Hydraulic Reservoir



- | | |
|-----------------|---------|
| 1 Breather | 3 Drain |
| 2 Oil Fill Port | |

Before proceeding, disconnect and lockout the main power supply and the electrical enclosure; and ensure that all high pressure water and hydraulic pressure has been bled from the system.



WARNING

Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before performing maintenance.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before performing maintenance.

1. Drain the oil reservoir by connecting the inlet hose from an oil transfer pump to the drain valve on the reservoir.
2. Open the shut off valve on the drain and pump the used oil out to a container.
3. Close the shut off valve and remove the inlet hose from the drain valve.

NOTE

Oil from a new drum does not meet the cleanliness requirements of the hydraulic system. For this reason, it is important to use an oil transfer pump that will force oil through the return filter into the reservoir.

4. Remove the cap from the fill port on the oil filter.

**CAUTION**

To ensure cleanliness, the oil fill port **must** be used to pump oil into the reservoir. Filling at this point guarantees the hydraulic oil will pass through the oil filter before entering the reservoir.

5. Connect the discharge hose from the oil transfer pump to the fill port and pump the fresh oil into the reservoir.

NOTE

If 3/4-inch BSPP threads are required, install the adapter located on the inside of the frame. When filling is complete, remove the adapter and install the fill port cap.

6. Check the oil sight gauge on the reservoir to ensure proper fill level.
7. Remove the hose from the case drain on the main hydraulic pump to make sure the pump case fills with oil. With the hose removed, head pressure from the reservoir will force oil into the pump case.

**CAUTION**

Oil in the pump case provides internal lubrication for the main hydraulic pump. Failure to fill the pump case with oil will allow air to become trapped inside, damaging the pump.

8. Disconnect the discharge hose from the fill port and replace the fill port cap.
9. Follow the initial start up sequence in Section 4, Operation, to ensure the system is filled with oil.
10. Check the sight gauge again and follow the same procedure to add additional oil if necessary.

Electric Motor Bump

Bumping is defined as allowing the electric motor to start rotating, but stopping it before the motor gets up to full speed.

Whenever the hydraulic reservoir is emptied or the hydraulic pump has been changed, bumping the electric motor is suggested. This procedure will ensure the hydraulic pump is full of oil and deter cavitation which will cause the hydraulic pump to fail prematurely.

Do not perform this procedure until the correct motor rotation and the presence of hydraulic oil in the hydraulic pump case drain line has been confirmed.

1. Start the pump in recirculation mode, count two seconds and turn the pump off.

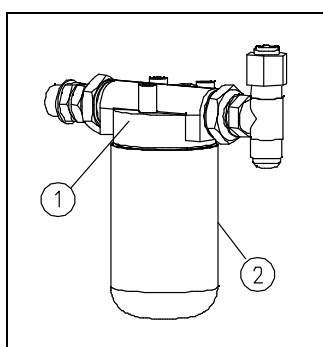
2. Repeat this process six times before allowing the hydraulic pump to create pressure.

Oil Filter Maintenance

If the filter element is not properly serviced and fills with debris, the oil will be forced through the relief valve, bypassing the filter. The bypass relief valve opens at 50 psi (3.4 bar).

The filter element must be replaced when the pressure gauge reading is 40 psi (2.8 bar) or greater during normal operating conditions. Normal operating conditions indicate the machine is running and the oil temperature has reached 115° F (46° C).

Figure 6-4: Oil Filter Assembly



1 Filter Head

2 Filter Element

1. Use a filter wrench to unscrew the filter element from the filter head. Make sure the old gasket is removed with the element.
2. Lubricate the gasket on the new element with fresh oil.
3. Use the filter wrench to screw the new element onto the filter head and hand-tighten. Do not over tighten.
4. Start the machine and check for leaks.

NOTE

If the pressure gauge reads 40 psi (2.8 bar) or greater, check the operating condition of the gauge or indicator. These components may require replacement.

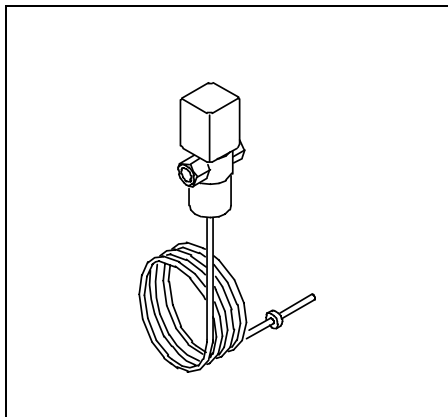
Operating Temperature Adjustment

The cooling water flow through the heat exchanger is regulated by the water modulating valve, a manually adjusted, thermostatic control valve. The valve is factory set to maintain the operating oil temperature at 115° F (46° C). It is adjusted by increasing or decreasing the spring tension on the valve.

NOTE

In most cases, adjustment will be required during commissioning and with seasonal changes to the cooling water temperature.

Figure 6-5: Water Modulating Valve



5. Locate the adjusting knob, a screwdriver slot on the top of the valve.
6. Use a flat screwdriver and turn counter-clockwise to compress the spring, slowing water flow and increasing temperature. Or; turn clockwise to reduce spring tension, increasing water flow and decreasing the temperature.
7. Monitor the sight gauge on the side of the reservoir until the adjusted temperature can be determined. It will take some time for the temperature in the oil reservoir to change.
8. Repeat steps 2 and 3 if necessary.

SECTION 7

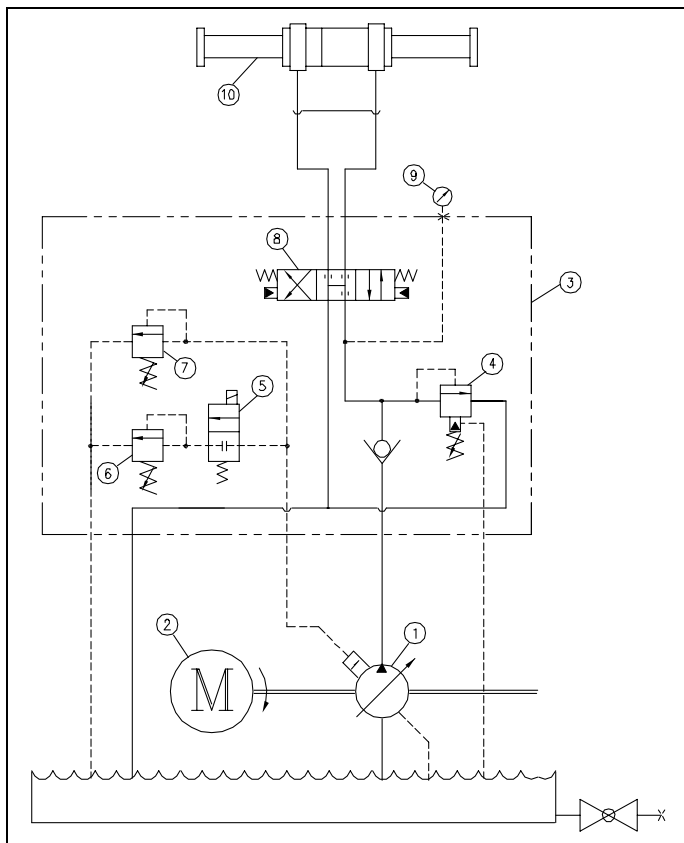
HYDRAULIC SYSTEM

7.1 Overview

The main hydraulic power circuit supplies the intensifier assembly with the hydraulic oil required to produce high pressure water. High pressure cutting water is generated from the oil pressure in the hydraulic cylinder.

System components include the electric motor, hydraulic pump, 4-way directional control valve and the hydraulic manifold. The manifold houses the high and low pressure control valves, hydraulic gauge, two pressure solenoid valve and the main system relief valve. The system relief valve monitors hydraulic oil pressure and provides system protection by limiting excess pressure.

Figure 7-1: Main Hydraulic Power Circuit



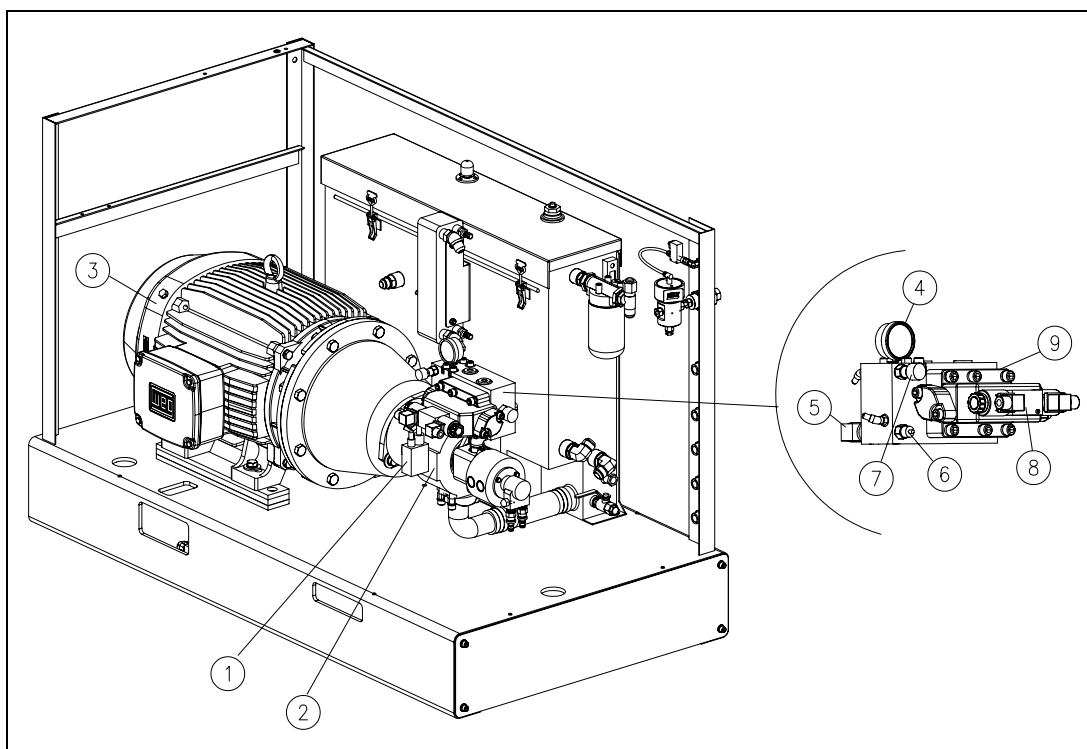
- | | | |
|-----------------------|-----------------------------|------------------|
| 1 Hydraulic Pump | 5 Solenoid Valve | 9 Pressure Gauge |
| 2 Electric Motor | 6 Low Pressure Control | 10 Intensifier |
| 3 Hydraulic Manifold | 7 High Pressure Control | |
| 4 System Relief Valve | 8 Directional Control Valve | |

7.2 Operation

The electric motor drives three pumps mounted in tandem; the main hydraulic pump, the recirculation pump and the booster pump. The motor drives the variable displacement, pressure compensated hydraulic pump by means of a flexible coupling.

Hydraulic fluid from the reservoir is drawn into the inlet, low pressure side of the hydraulic pump. Oil delivered to the pump should be maintained at 110-115° F (43-46° C). Hydraulic fluid then enters the bottom of the manifold through an internal anti-rotation check valve. After a shutdown, the anti-rotation check valve prevents the pump from running backwards.

Figure 7-2: Hydraulic System Components



- | | |
|-------------------------------|-----------------------------|
| 1 High/Low Limit Compensators | 6 Low Pressure Control |
| 2 Hydraulic Pump | 7 High Pressure Control |
| 3 Electric Motor | 8 Directional Control Valve |
| 4 Pressure Gauge | 9 Relief Valve |
| 5 High/Low Solenoid Valve | |

The main system relief valve provides system protection by monitoring the oil pressure entering the manifold. If the hydraulic pressure exceeds 3,408 psi (235 bar), the valve opens to limit the pressure. The valve is factory calibrated and is not serviceable. A drain line from the valve prevents oil from collecting behind the relief valve to ensure a constant pressure under all operating conditions.

The hydraulic system operates at high or low pressure settings up to the maximum flow capacity of the hydraulic pump. The high and low limit compensators mounted on the pump regulate the flow of hydraulic fluid to maintain constant operating pressures. Operating pressures are set and adjusted at the high and low pressure control valves on the manifold.

**CAUTION**

The high and low limit compensators regulate the flow of hydraulic fluid to the system by controlling the angle of the swashplate. If the oil is not properly maintained, the compensators can become blocked with debris. As a result, pump control will be lost and you will not be able to create hydraulic oil pressure.

The normally closed, two pressure solenoid valve is controlled by the operator's selection of high or low pressure. The valve is closed while operating in high pressure and is open during low pressure operation. A light on the solenoid connector indicates low pressure operation.

A reference gauge on the top of the manifold displays hydraulic pressure to the intensifier. When the intensifier shifts, it is normal for the pressure to quickly fall and then rise again.

The 4-way directional control valve directs pressurized oil to one end the hydraulic cylinder and returns fluid to the reservoir from the opposite end, causing the intensifier to stroke. The movement is controlled hydraulically by a pilot valve that is electronically operated by two solenoids, energized by the PLC. Indicators light up as each solenoid is energized.

The directional control valve sends flow to the hydraulic cylinder in one direction until the hydraulic piston activates the proximity switch at the end of the stroke. The activated switch sends a signal to the PLC to reverse the direction of flow. The piston then moves in the opposite direction until it activates the proximity switch at the opposite end of the stroke.

7.3 Service and Maintenance Procedures

The extreme duty cycles demanded of the hydraulic system make routine inspection and maintenance acutely important. Leaks must be detected and remedied as soon as possible.

The operating pressure settings must be checked daily, and the electric motor must be inspected at regular intervals. It is also possible for the flexible coupling to fail and require replacement.

NOTE

Refer to Section 12, Parts List for a complete listing of replacement parts and part numbers.

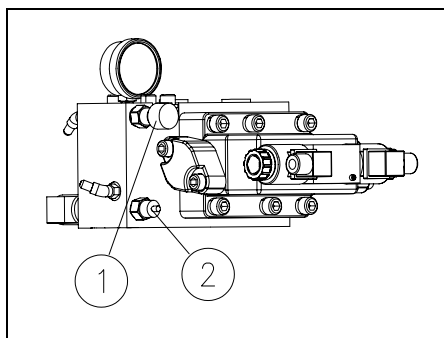
Hydraulic Operating Pressure

Hydraulic operating pressure settings should be checked daily and adjusted as necessary. High and low operating pressure is adjusted at the high and low pressure control valves per the specifications in Table 7-1.

Table 7-1
Hydraulic Operating Pressure Limits

	Adjustment		Pressure Limits	
	Increase	Decrease	Minimum	Maximum
High Pressure	Clockwise	Counter-clockwise	290 psi (20 bar)	3,000 psi (207 bar)
Low Pressure	Clockwise	Counter-clockwise	290 psi (20 bar)	800 psi (55 bar)

Figure 7-3: High/Low Pressure Controls



- 1 High Pressure Control 2 Low Pressure Control

1. Check the operating pressure to determine if adjustment is necessary.
2. If high pressure adjustment is required, loosen the locking thumbscrew on the high pressure control valve by turning counter-clockwise.
3. Turn the knob on the control valve clockwise to increase operating pressure. Turn the knob counter-clockwise to decrease pressure.
4. Tighten the locking nut and verify the high pressure setting.
5. If low pressure adjustment is required, loosen the locking nut on the low pressure control valve by turning counter-clockwise.
6. Turn the hex clockwise to increase operating pressure. Turn the hex counter-clockwise to decrease pressure.
7. Tighten the locking nut and verify the low pressure setting.

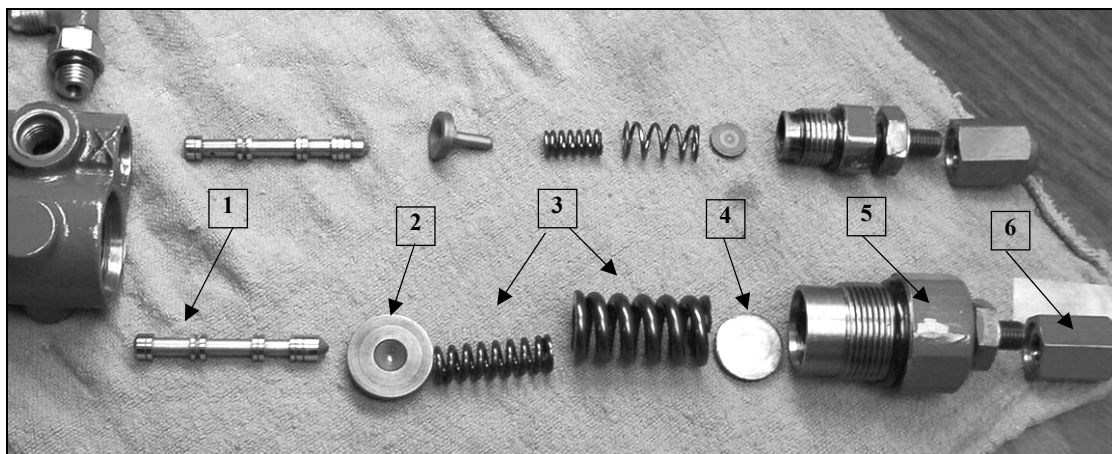
Motor Maintenance

The motor should be inspected at regular intervals, approximately every 500 hours of operation or every three months, whichever occurs first. Keep the motor clean and the ventilation openings clear.

Hydraulic Compensator Maintenance

The high and low limit compensators regulate the flow of hydraulic fluid to the system. The compensators can become blocked with debris resulting in loss of pump control.

Figure 7-4: Hydraulic Compensator Components



- | | | |
|--------------|-----------------|---------------|
| 1 Spool | 3 Springs | 5 Plug Nut |
| 2 Spring Cup | 4 Spring Collar | 6 Sealing Cap |

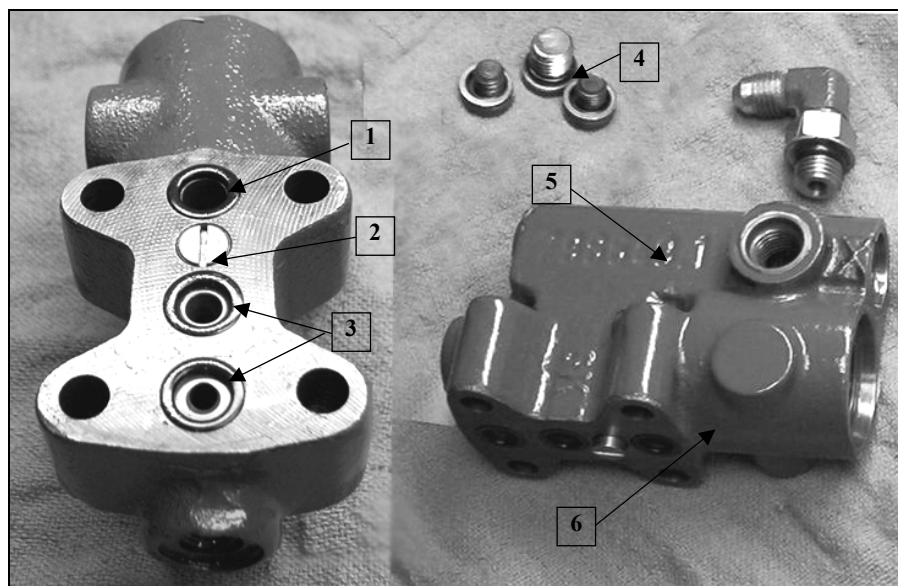


WARNING

Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before performing maintenance on the system components.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before performing maintenance.

1. Remove the hydraulic hose from the low limit compensator.
2. Remove the four socket screws that attach the compensators to the pump.
3. Remove the compensators and then remove the three plugs and o-rings on the back of the housing.



- | | | |
|-----------|----------|--------------------------|
| 1 O-Ring | 3 O-Ring | 5 Low Limit Compensator |
| 2 Orifice | 4 Plug | 6 High Limit Compensator |

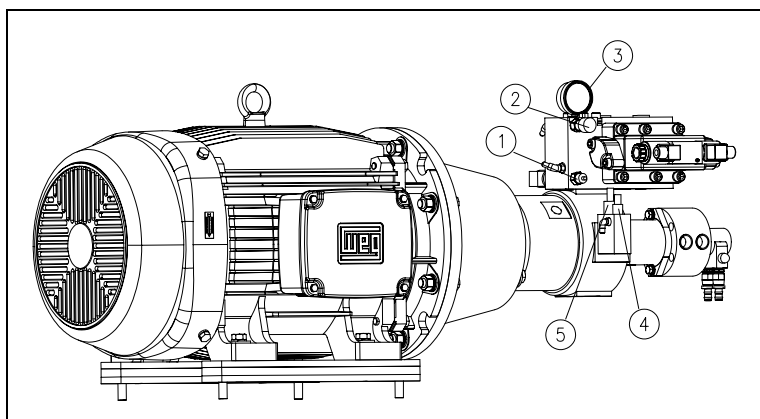
4. Disassemble the compensators one at a time by first removing the hexagon sealing cap.
5. Loosen the lock nut, and then remove the plug nut.
6. Disassemble the plug by removing the spring collar, springs, spring cup and spool.
7. Clean the housing and all components with clean fluid and carefully dry with air.
8. Check and clean the small internal passages in the spools.
9. Check and clean the orifices in both spools.
10. Assemble in the reverse order, ensuring that the screw slot on the orifice is aligned with the long axis of the body.



CAUTION

When the compensators are removed, the machine loses adjustment. The compensators must be reset before operation can begin.

11. Start the machine and select the low pressure operating mode on the display panel.
12. Deadhead the machine.



- | | |
|----------------------------|--------------------------|
| 1 Low Pressure Control | 4 Low Limit Compensator |
| 2 High Pressure Control | 5 High Limit Compensator |
| 3 Hydraulic Pressure Gauge | |

13. Set the high and low pressure control valves on the hydraulic manifold to the minimum setting by turning then counter-clockwise.
14. Set the compensators to the minimum setting by turning the adjusting screws counter-clockwise.
15. Select high pressure operating mode on the display panel and set the high pressure control valve on the hydraulic manifold to the maximum setting by turning the knob clockwise.
16. Turn the adjusting screw on the high limit compensator clockwise until the hydraulic reference gauge reads 3,000 psi (207 bar).
17. Select low pressure operating mode on the display panel and turn the adjusting screw on the low limit compensator clockwise until the reference gauge reads 290 psi (20 bar). Lock the adjustment screw in place.
18. Select high pressure operating mode on the display panel and turn the knob on the high pressure control valve counter-clockwise until the reference gauge reads 2,000 psi (138 bar).
19. Open the high pressure water control valve, allowing water to flow. Set the desired high operating pressure by adjusting the high pressure control valve.
20. While the machine is running and high pressure water is flowing, select low pressure operating mode. Set the desired low operating pressure by adjusting the low pressure control valve.



SECTION 8

ELECTRICAL SYSTEM

8.1 Overview

The Jetline™ series is equipped with integral motor starter and control circuitry, enclosed in the electrical panel. The operator controls the machine primarily through a function-button control panel that communicates with the programmable logic controller (PLC). A series of sensors provide automatic shutdown logic and diagnostics.

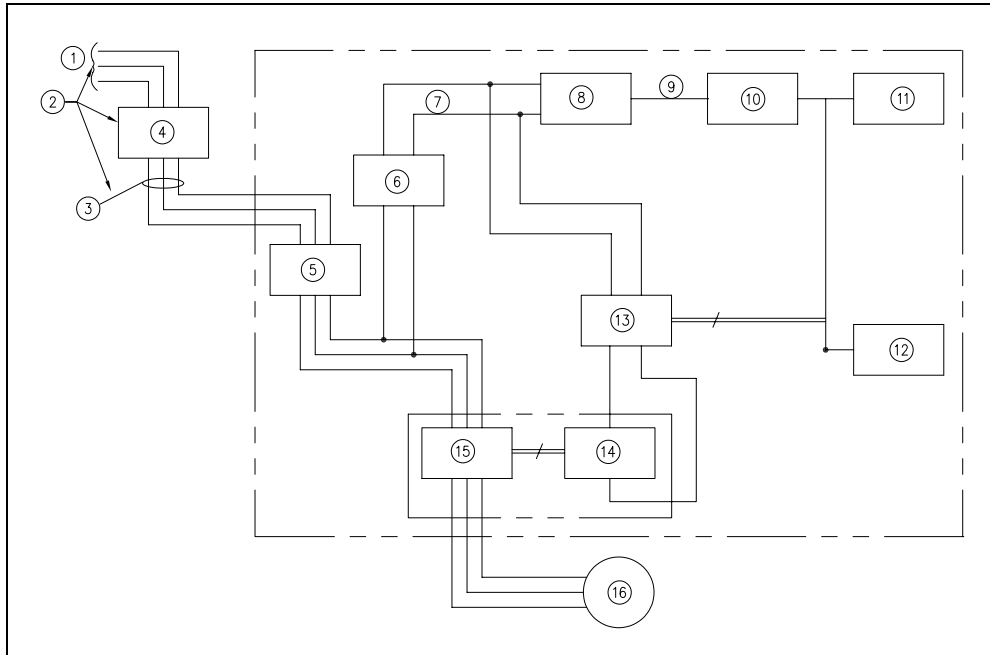
Major system components include the electric motor, control panel, high voltage and control components, and the wiring harness that connects the sensors and solenoid valves to the PLC.

8.2 Operation

Electrical power from the utility grid enters the main circuit breaker/disconnect on the electrical enclosure door as 3-phase alternating current. The power is then distributed in two directions. The 3-phase AC, at the voltage provided from the grid, is routed to the motor starter contactor(s) and then to the main motor. Single phase AC is routed to the transformer.

The transformer converts the incoming voltage to 230 volt AC that is routed to both the motor starter contactor(s) and to the power supply. The power supply then provides 24 volt direct current to the control circuits, including the emergency stop logic, the PLC and the display panel.

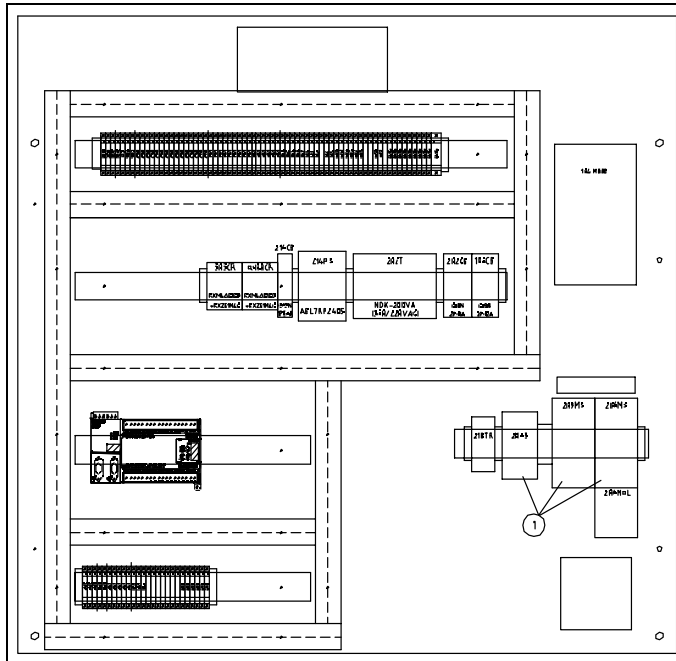
Figure 8-1: Electrical Control Power



- | | | |
|-------------------------------------|----------------|-----------------------------|
| 1 Line | 7 230V AC | 12 Display Panel |
| 2 Customer Supplied | 8 Power Supply | 13 Motor Control Relay |
| 3 Line Voltage (3-Phase Line Power) | 9 24V DC | 14 Contactor Coil (230V AC) |
| 4 Wall Disconnect | 10 E-Stop | 15 Motor Starter Contactor |
| 5 Circuit Breaker/Disconnect | 11 PLC | 16 Motor |
| 6 Transformer | | |

The motor starter contactors are solenoid operated by 230 volt AC control power. The contactors are arranged in a wye-delta starter circuit. Wye-delta starter circuits are typically installed in all low voltage machines that require high current draw. Three, 3-phase contactors are used to start the motor slowly, minimizing the initial current draw.

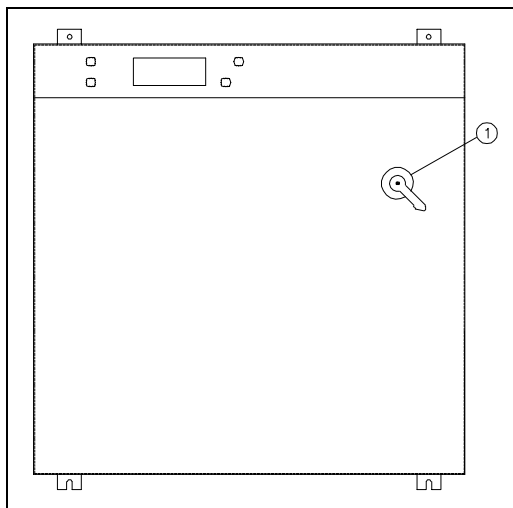
Figure 8-2: Wye-Delta Configuration



- 1 Three, 3-Phase Contactors

The circuit breaker/door disconnect provides the primary over current protection for the machine. All power is automatically disconnected from the machine when the main disconnect on the enclosure door is opened. However, power is still present on the input side of the circuit breaker/door disconnect. The only way to isolate all power to the machine is to turn the customer installed main power disconnect off.

Figure 8-3: Electrical Enclosure Door



- 1 Circuit Breaker/Disconnect

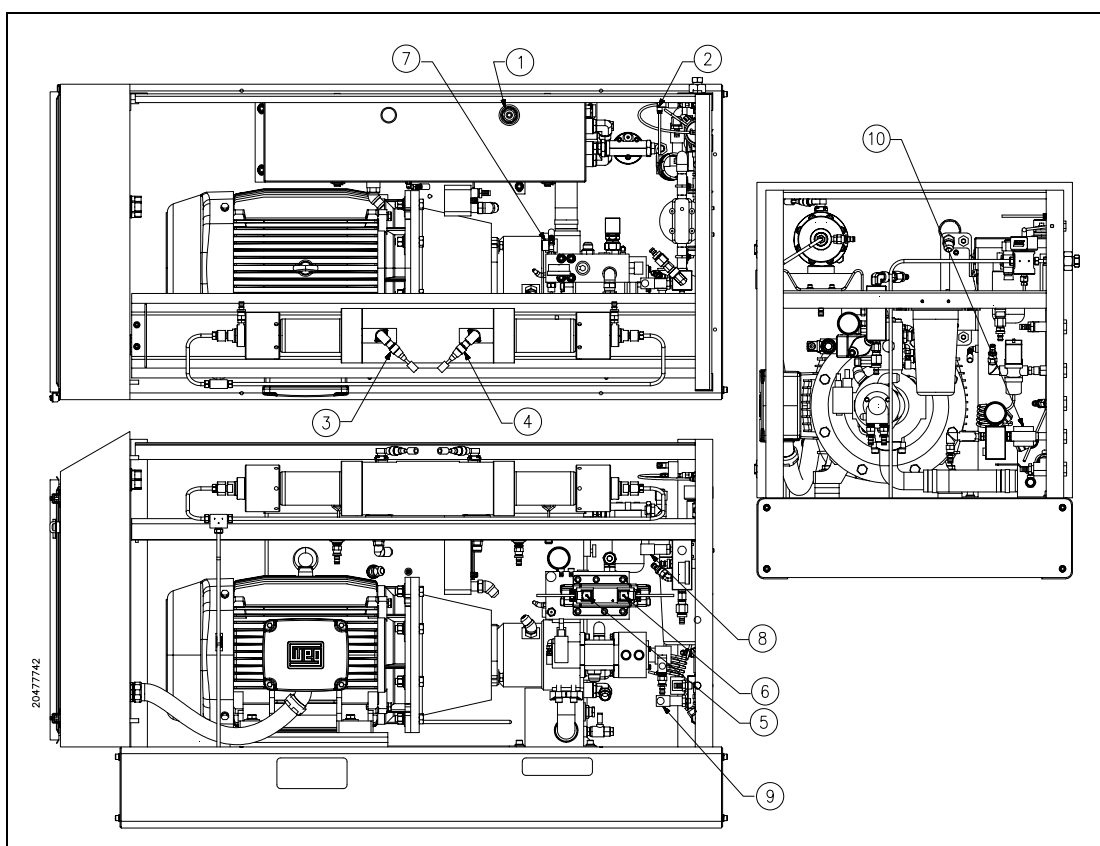
NOTE

See Section 2, Installation, regarding specifications for the customer installed main power disconnect.

Sensors and Solenoids

Warning and shutdown sensors monitor operating conditions, and electronically operated solenoids provide basic intensifier shift control. The harness cable connects these sensors and solenoids to the PLC.

Figure 8-4: Sensors and Solenoids



- | | | |
|--------------------------------|----------------------------------|-------------------------------|
| 1 Oil Level/Temperature Switch | 5 4-Way Valve 'A' Solenoid | 9 Inlet Water Pressure Switch |
| 2 Dump Valve | 6 4-Way Valve 'B' Solenoid | 10 Water Inlet Valve |
| 3 Left Proximity Switch | 7 2-Pressure Solenoid | |
| 4 Right Proximity Switch | 8 Booster Outlet Pressure Switch | |

Table 8-1
Sensors and Solenoids

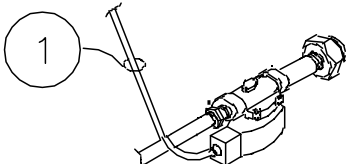
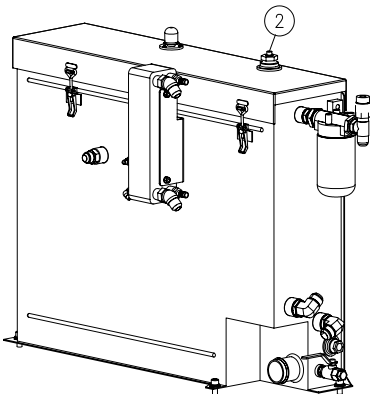
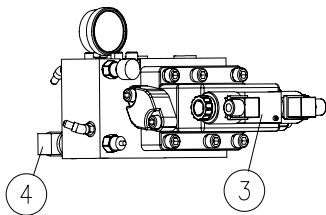
Component	Function
<i>Inlet Water Solenoid Valve</i>	
	<p>1 The normally closed, inlet water solenoid valve is located at the service bulkhead. When the control power is turned on, the valve opens and allows low pressure cutting water to enter. The solenoid valve functions as a safeguard by closing if an overstroke condition occurs.</p>
<i>Hydraulic Reservoir</i>	
	<p>2 The temperature/low level switch monitors the oil temperature and level in the reservoir. Although the float switch and the temperature switch are combined in a single unit, the two switches function independently.</p> <p>If the operating oil temperature exceeds 145° F (63° C) an automatic shutdown occurs. If the hydraulic fluid level falls below specifications, a low oil level shutdown occurs.</p>
<i>Hydraulic Manifold</i>	
	<p>3 The 4-way directional control valve shifts the hydraulics back and forth to the intensifier. A shift valve directs pressurized oil to one end of the hydraulic cylinder and returns fluid to the reservoir from the opposite end, causing the intensifier to stroke. The movement is controlled electronically by two solenoids, signaled by the PLC. As power is directed from one solenoid to the other, LEDs are alternately illuminated.</p> <p>4 When low pressure is selected, a normally closed, solenoid valve is activated. The valve remains closed while operating in high pressure and is held open electrically during low pressure operation. An illuminated LED on the solenoid indicates low pressure operation.</p>

Table 8-1
Sensors and Solenoids

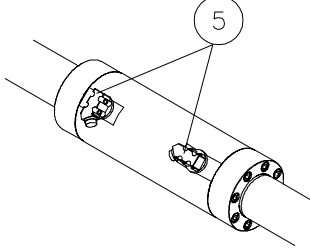
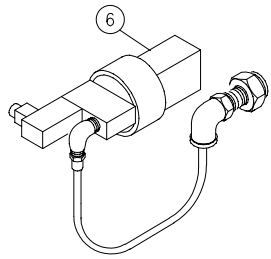
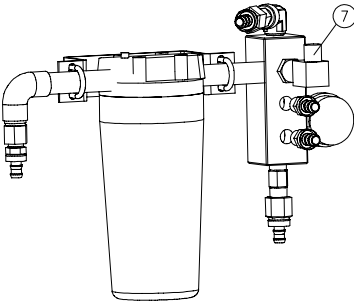
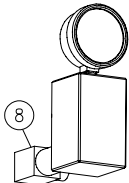
Component	Function
<p><i>Hydraulic Cylinder</i></p> 	<p>5 As pressurized hydraulic oil is sent to one side of the hydraulic cylinder, it pushes against the piston, moving it in one direction until it activates the proximity switch at the end of the stroke. The hydraulic flow is then sent to the opposite side of the cylinder, and the piston reverses direction until it activates the proximity switch at the opposite end of the stroke.</p> <p>The green light on the proximity switch indicates there is power to the switch. The light turns red when the switch is activated. The proximity switches are magnetically activated by the presence of the metallic surface of the piston. When the switch is activated, it sends a signal to the PLC to change the flow of the directional control valve and reverse direction.</p>
<p><i>High Pressure Safety Dump Valve</i></p> 	<p>6 The safety dump valve releases the stored pressure in the intensifier and high pressure delivery lines. The high pressure dump valve assembly includes a normally open high pressure water valve and a solenoid operated air valve.</p> <p>The normally open pneumatic dump valve is held closed by air pressure. When the air supply is interrupted from an emergency stop or a normal stop, the valve opens and allows water to flow through the valve. Pressure is released in the intensifier and the high pressure water stream exits through the drain.</p>

Table 8-1
Sensors and Solenoids

Component	Function
<i>Low Pressure Water Filter Assembly</i>	
	<p>7 To ensure adequate water pressure and supply to the intensifiers, the discharge pressure is monitored by a 60 psi pressure switch. An automatic shutdown occurs if the pressure is below 60 psi (4 bar).</p>
	<p>8 The 30 psi pressure switch, mounted on the inlet manifold, monitors the inlet cutting water. If the pressure drops below 30 psi (2 bar) the switch activates an automatic shutdown circuit, protecting the booster pump from damage due to insufficient water supply pressure.</p>

8.3 Service and Maintenance Procedures

Electrical components require minimal service. The proximity switches on the hydraulic cylinder may require replacement.

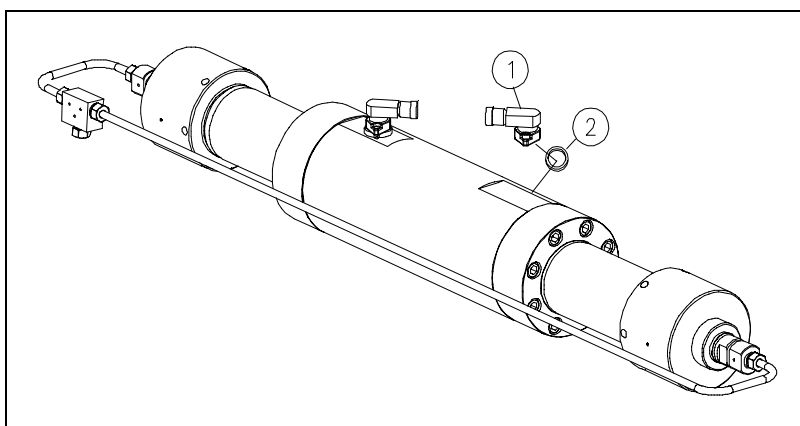
NOTE

Refer to Section 12, Parts List for a complete listing of replacement parts and part numbers.

Proximity Switch Maintenance

A proximity switch has failed and needs to be replaced if the LEDs do not change state, indicating they are not sensing the piston, if an LED flashes continuously, or if the appropriate input is not noted on the PLC processor annunciator light panel in the electrical enclosure.

Figure 8-5: Proximity Switch



1 Proximity Switch

2 O-Ring Spacer

1. Turn the machine off and observe the appropriate Lockout/Tagout procedures.



WARNING

Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before performing maintenance on the system components.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before performing maintenance.

2. Remove the electrical cable from the failed proximity switch.
3. Remove the two socket head screws, the failed switch and the o-ring spacer.

4. Install a new proximity switch by positioning the o-ring spacer and the switch. Ensure the o-rings are correctly oriented.
5. Apply JL-M grease to the threads on the screws and tighten to 140-160 in-lbs (16-18 Nm).

**CAUTION**

Ensure that the proximity switch is properly installed and secured prior to starting the machine. Failure to tighten the two hold down screws on each switch will result in the spray of hydraulic oil.



SECTION 9

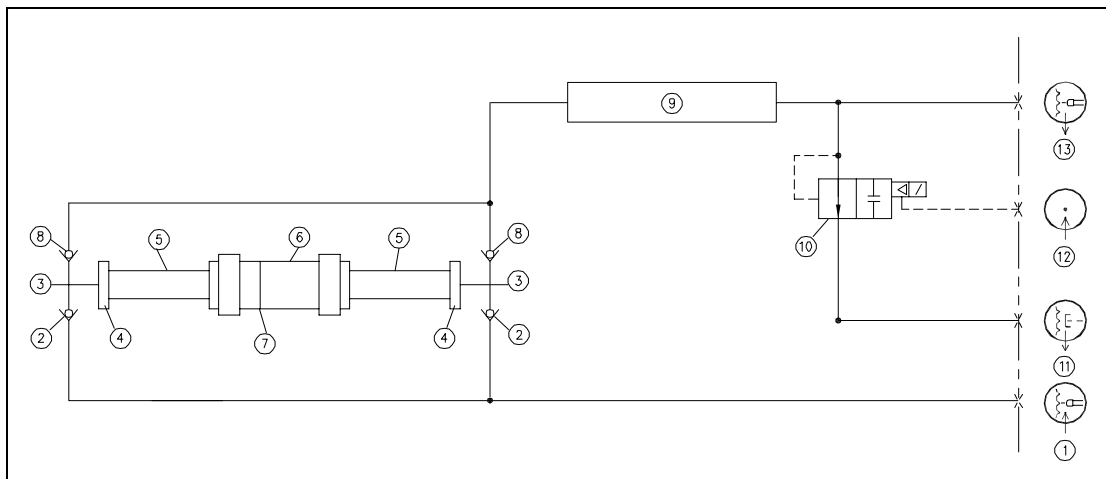
HIGH PRESSURE WATER SYSTEM

9.1 Overview

The high pressure water system is supported by both the cutting water supply circuit and the hydraulic circuit. Cutting water of sufficient flow and pressure is routed from the cutting water supply circuit to the intensifier where it is pressurized up to 55,000 psi (3,792 bar) and delivered to the cutting head.

The directional control valve in the hydraulic system creates the stroking action of the intensifier by sending pressurized hydraulic oil to one side of the hydraulic cylinder or the other. As the flow is sent to one side, hydraulic fluid is returned to the reservoir from the opposite side.

Figure 9-1: High Pressure Water System Circuit



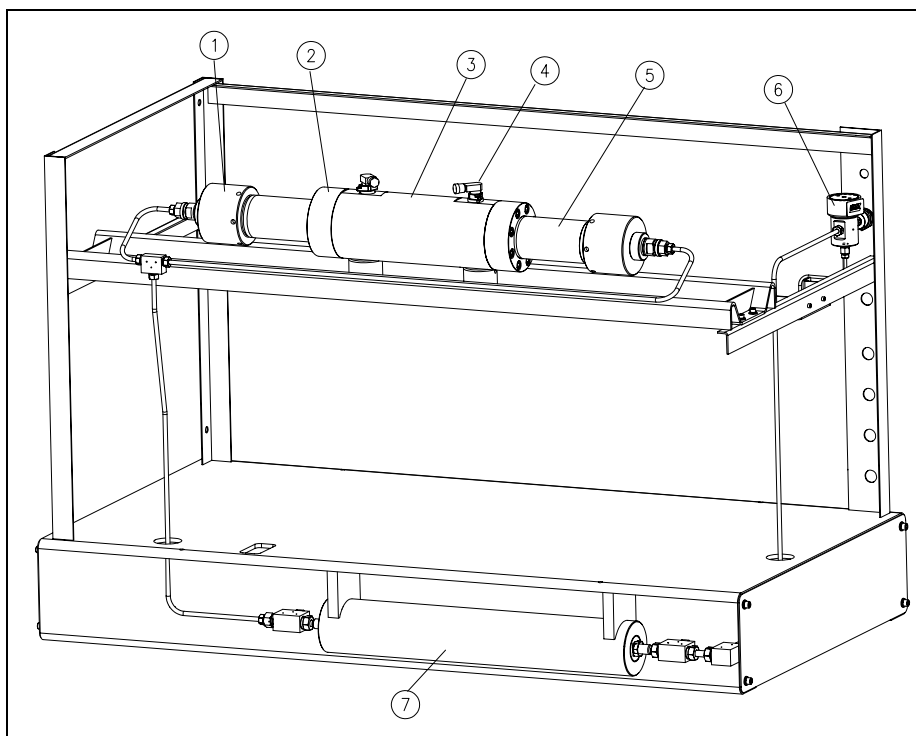
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|--------------------------|-------------------------|----------------------|
| 1 Cutting Water In | 6 Hydraulic Cylinder | 11 Drain |
| 2 Inlet Check Valve | 7 Hydraulic Piston | 12 Air In |
| 3 Sealing Head | 8 Discharge Check Valve | 13 Cutting Water Out |
| 4 Soft Seal End Cap | 9 Attenuator | |
| 5 High Pressure Cylinder | 10 Safety Dump Valve | |

System components include a double-ended hydraulic cylinder; reciprocating piston assembly; high pressure cylinders attached to each end of the hydraulic cylinder; two plungers, sealing heads and soft seal end caps; a one liter capacity attenuator, and a safety dump valve. Sophisticated check valves and seal assemblies ensure hydraulic oil, and the low pressure and high pressure water travel in the appropriate direction. Warning and shutdown sensors monitor system temperature and fluid levels to safeguard against component damage.

9.2 Operation

The directional control valve sends pressurized hydraulic oil to one side of the hydraulic cylinder. The pressurized oil pushes against the piston, moving it in one direction until it activates the proximity switch at the end of the stroke. The hydraulic flow is then sent to the opposite side of the cylinder, and the piston reverses direction until it activates the proximity switch at the opposite end of the stroke.

Figure 9-2: High Pressure Water System



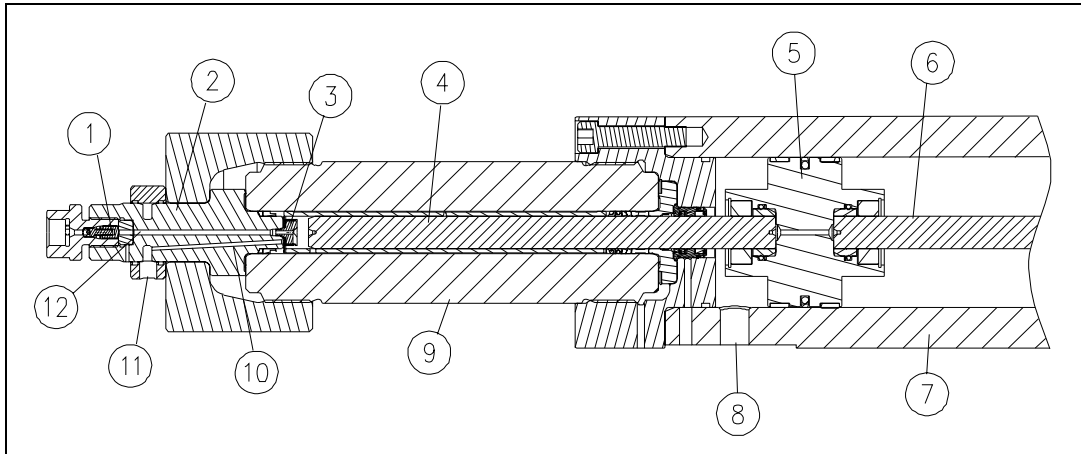
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|---------------------------|--------------------------|
| 1 Soft Seal End Cap | 5 High Pressure Cylinder |
| 2 Hydraulic Cylinder Head | 6 Safety Dump Valve |
| 3 Hydraulic Cylinder | 7 Attenuator |
| 4 Proximity Switch | |

The green light on the proximity switch indicates there is power to the switch. The red light illuminates when the switch is activated. The proximity switches are magnetically activated by the presence of the metallic surface of the piston. When the switch is activated, it sends a signal to the PLC to change the flow of the directional control valve and reverse direction.

As the pressurized oil pushes the piston in one direction, the plunger on that end extends and pushes against the water in the high pressure cylinder, increasing the pressure up to 55,000 psi (3,792 bar). When the piston reverses direction, the plunger retracts and the plunger in the opposite cylinder extends to deliver the high pressure water.

Low pressure water is routed through the inlet water ports to the inlet passages in the sealing heads. When the plunger retracts, the inlet check valve opens to allow water to fill the high pressure cylinder. When the plunger extends to create high pressure water, the inlet valve closes to seal the inlet passage and the discharge check valve opens to allow the high pressure water to exit the cylinder. As the plunger retracts, the discharge check valve closes.

Figure 9-3: High Pressure Cylinder



- | | | |
|-------------------------|----------------------|--------------------------|
| 1 Discharge Check Valve | 5 Hydraulic Piston | 9 High Pressure Cylinder |
| 2 Sealing Head | 6 Retracted Plunger | 10 Inlet Water Passage |
| 3 Inlet Check Valve | 7 Hydraulic Cylinder | 11 Inlet Water Port |
| 4 Extended Plunger | 8 Hydraulic Oil In | 12 Outlet Water Passage |

The intensifier is a reciprocating pump. As the piston and plungers move from one side to the other, high pressure water exits one side of the intensifier as low pressure water fills the opposite side.

The high pressure water is then routed to the attenuator. The attenuator acts as a shock absorber to dampen pressure fluctuations and ensure a steady and consistent supply of water. From the attenuator, the high pressure water exits to the cutting head.

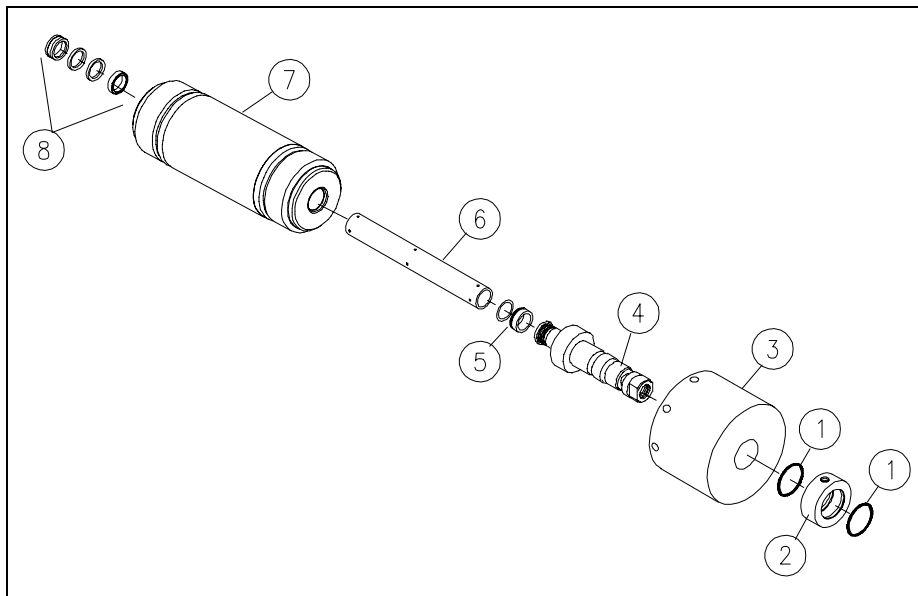
The safety dump valve releases the stored pressure in the intensifier and high pressure delivery lines. The high pressure dump valve assembly includes a normally open high pressure water valve and an electrically controlled air valve.

The normally open pneumatic dump valve is held closed by air pressure. When the air supply is interrupted and exhausted from an emergency stop or a normal stop, the valve opens and allows water to flow through the valve. Pressure is released in the intensifier and the high pressure water stream exits through the drain.

9.3 System Components

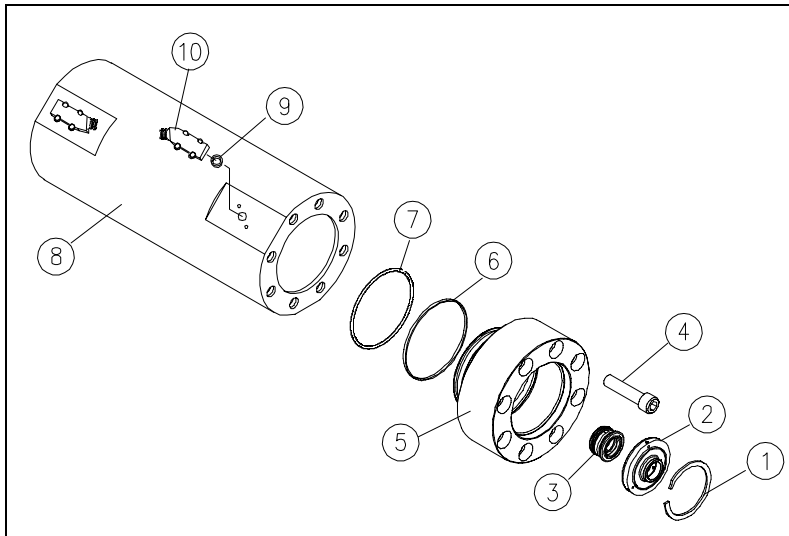
The following figures illustrate the individual high pressure water system components.

Figure 9-4: High Pressure Cylinder Assembly



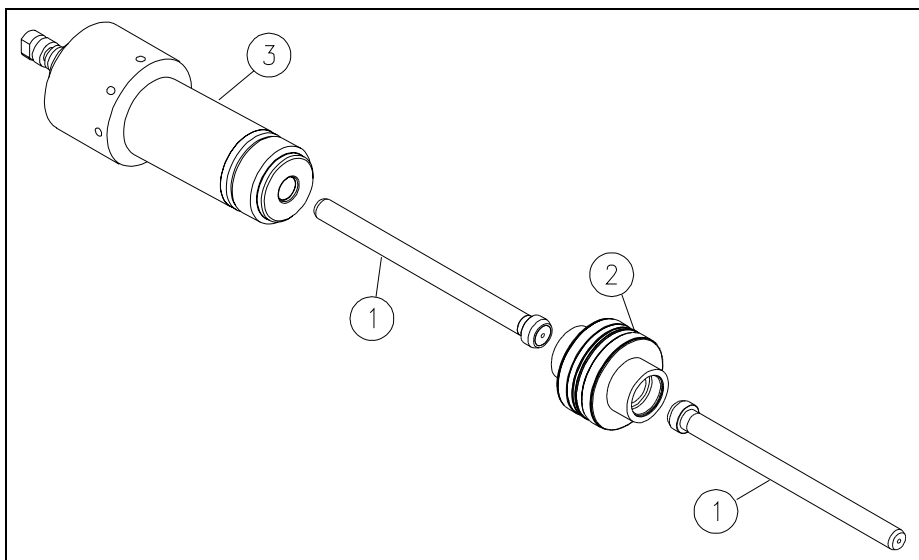
- | | |
|-----------------------|-------------------------------|
| 1 O-Ring | 5 Sealing Head Seal Assembly |
| 2 Sealing Head Collar | 6 Cylinder Liner |
| 3 Soft Seal End Cap | 7 High Pressure Cylinder |
| 4 Sealing Head | 8 High Pressure Seal Assembly |

Figure 9-5: Hydraulic Cylinder Assembly



- | | |
|----------------------------|----------------------|
| 1 Retaining Ring | 6 Backup Ring |
| 2 Bushing Retainer Flange | 7 O-Ring |
| 3 Hydraulic Seal Cartridge | 8 Hydraulic Cylinder |
| 4 Socket Head Screw | 9 O-Ring Spacer |
| 5 Hydraulic Cylinder Head | 10 Proximity Switch |

Figure 9-6: Hydraulic Piston



- | | |
|-----------------------------|-----------------------------------|
| 1 Plunger | 3 High Pressure Cylinder Assembly |
| 2 Hydraulic Piston Assembly | |



9.4 Service and Maintenance Overview

Never perform any type of maintenance on the high pressure water system while it is pressurized. Always turn the power off and bleed the high pressure water before servicing. Pressing the emergency stop button turns the control power off to the intensifier, and bleeds high pressure water through the dump valve.

Improper assembly can lead to the premature failure of components. Maintenance procedures must be followed carefully; components must be properly cleaned prior to assembly and tightened to the correct torque specifications.

Some high pressure components are not serviceable at the customer level, others require precise refinishing. KMT Waterjet Systems offers maintenance and refinishing services for these components.

NOTE

Refer to Section 12, Parts List for a complete listing of replacement parts and part numbers.



Torque Specifications

Table 9-1, Torque Specifications, details the torque specifications and tightening sequences for the high pressure components and connections.

Table 9-1
Torque Specifications
High Pressure Water System

Hydraulic Cylinder Head	
Socket Head Screws	8 (M14) each
Torque	75-80 ft-lbs (102-108 Nm)
Hex Key	M12
Proximity Switch	
Socket Head Screws	2 (M6) each
Torque	140-160 in-lbs (16-18 Nm)
Hex Key	M5
Sealing Head	
Discharge Gland Nut	130 ft-lbs (176 Nm)
Poppet Retainer	25-30 in-lbs (2.8-3.4 Nm)
Pneumatic Control Valve	
HP Adapter	25 ft-lbs (34 Nm)
1/4-inch Outlet to Drain	25 ft-lbs (34 Nm)
Pneumatic Actuator	5 ft-lbs (7 Nm)
3/8-inch HP Gland Nut	50 ft-lbs (68 Nm)
High Pressure Fittings	
1/4" HP Gland Nut	25 ft-lbs (34 Nm)
3/8" HP Gland Nut	50 ft-lbs (68 Nm)
9/16" HP Gland Nut	110 ft-lbs (149 Nm)

Specialized Maintenance Tools

KMT Waterjet has designed tools to facilitate the removal and installation of specialized system components. These tools are illustrated in Figure 9-7, Specialized Maintenance Tools, and part numbers are provided in Table 9-2.

Figure 9-7: Specialized Maintenance Tools

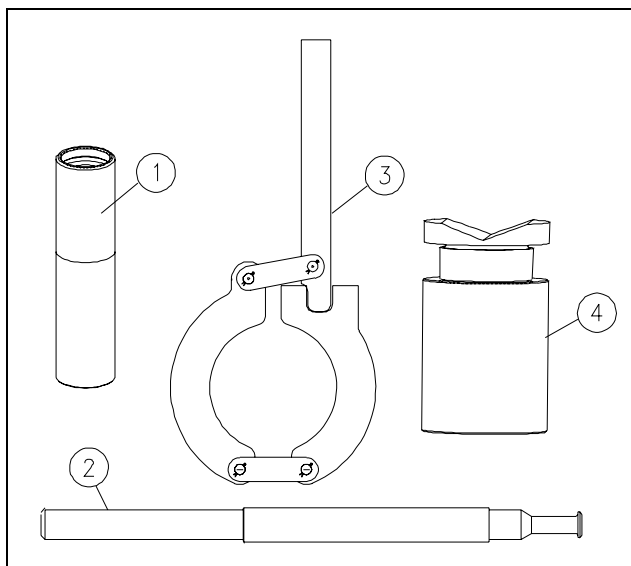


Table 9-2
Specialized Maintenance Tools
High Pressure Water System

		Part Number
1	Cartridge Removal Tool	72113886
2	Seal Removal Tool	10148674
3	Cylinder Wrench	05066139
4	Vee Block Cradle	20494488

9.5 High and Low Pressure Water Piping

Before performing any maintenance on the high pressure components, it is necessary to remove the high and low pressure water piping. The following procedure should be used to remove and install the piping.



WARNING

Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before performing maintenance on the high pressure system components.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before performing maintenance.

1. Turn the cutting water supply off.
2. Loosen and remove the high pressure gland fitting connected to the discharge high pressure check valve. Move the tubing to clear the work area.
3. Loosen and remove the low pressure piping connected to the inlet water port on the sealing head collar.
4. When the required maintenance has been completed and the components reassembled, connect the low pressure water piping to the inlet water port on the sealing head collar.
5. Apply Pure Goop to the threads on the high pressure gland fitting. Before installing the high pressure fitting, ensure proper collar position, 1-1/2 to 2-1/2 threads should be exposed. Install and tighten the fitting to the torque specifications in Table 9-1.
6. Turn the cutting water supply on and check for low pressure leaks.
7. Remove the cutting orifice and start the machine. Operate in low pressure mode to flush the high pressure passages.
8. Install the orifice and operate at high pressure to check for leaks.

9.6 High Pressure Cylinder Assembly

The high pressure cylinder assembly must be disassembled to service the inlet check valves, sealing head seal assembly, plunger, high pressure seals, hydraulic piston and hydraulic seal cartridge. Disassembly is not required when servicing the discharge check valves.

High Pressure Cylinder Assembly Removal

Prior to removing electrical power or any high or low pressure piping, bring the hydraulic piston in the left or right stop position to facilitate maintenance. The plunger will extend in the selected direction, allowing full exposure when the unit is disassembled. Refer to Section 4, Operation.

1. Turn the machine off and observe the appropriate Lockout/Tagout procedures.



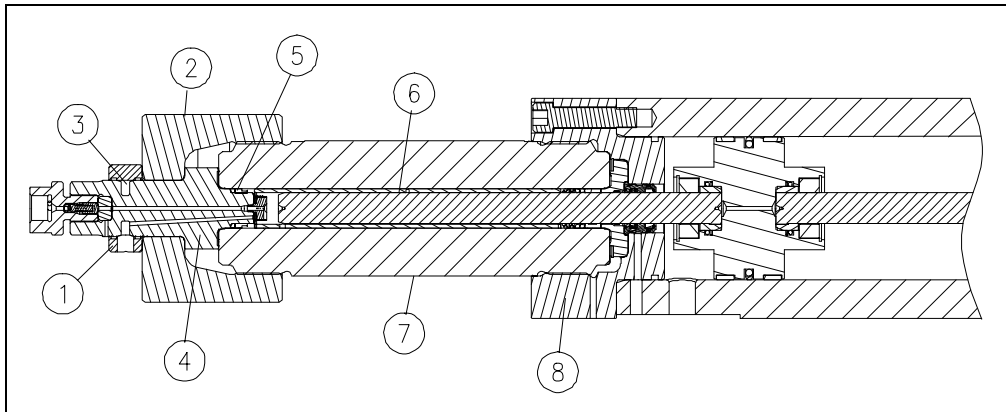
WARNING

Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before proceeding.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before proceeding.

2. Disconnect the high and low pressure water piping, following the procedure, High and Low Pressure Water Piping.
3. Gently pry the sealing head collar off of the sealing head.

Figure 9-8: High Pressure Cylinder Assembly Removal



- | | |
|-----------------------|------------------------------|
| 1 Sealing Head Collar | 5 Sealing Head Seal Assembly |
| 2 Soft Seal End Cap | 6 Cylinder Liner |
| 3 Inlet Water Groove | 7 High Pressure Cylinder |
| 4 Sealing Head | 8 Hydraulic Cylinder Head |

4. Position a pin spanner wrench on the soft seal end cap to turn counter-clockwise. Position a cylinder wrench on the high pressure cylinder to turn clockwise. Break the end loose. It may be necessary to tap the spanner wrench with a plastic hammer.
5. Unscrew the end cap until it is flush with the inlet water groove on the sealing head. With a screwdriver in the groove, supported by the end cap, gently pry the sealing head out as far as possible. Repeat this process until the sealing head is loose from the high pressure cylinder.

6. Unscrew and remove the end cap and sealing head from the cylinder.
7. Use the seal removal tool to remove the sealing head seal components from the cylinder.

To service the high pressure seals, plunger, hydraulic piston or hydraulic seal cartridge continue with Step 8.

8. Remove the cylinder liner.
9. Position the vee block cradle under the high pressure cylinder to support the weight. Unthread and remove the cylinder from the hydraulic cylinder head and plunger. The cylinder can be rotated with the cylinder wrench or by hand.

**CAUTION**

Due to the weight of the high pressure cylinder, adequate support must be provided to prevent damage to the plunger or seals during removal and installation.

NOTE

If thread or metal surface galling is detected during cylinder removal, galled surfaces and threads must be filed, sanded and lubricated prior to reassembly. See the procedure, High Pressure Cylinder Maintenance.

High Pressure Cylinder Assembly Installation

1. Verify that the high pressure cylinder threads and alignment surfaces are adequately cleaned and lubricated with Pure Goop, and that the threads have been sanded and dressed if galling was encountered during removal.
2. Verify that the high pressure seal assembly is correctly installed. While supporting the weight with the vee block cradle, align the cylinder with the plunger and the hydraulic cylinder head. Carefully push the cylinder into position until the threads are ready to engage.
3. Thread the cylinder into the hydraulic cylinder head. The cylinder will become difficult to rotate as it slides over the high pressure seal assembly. Use the cylinder wrench as necessary.

NOTE

If galling occurs during threading, remove the high pressure cylinder and inspect the mating surfaces and threads. Repair surfaces, thoroughly clean, lubricate and thread the cylinder into the hydraulic cylinder head.

4. Hand-tighten the cylinder with the cylinder wrench. Tap the wrench with the palm of your hand to tighten.

5. Clean and install the cylinder liner.
6. Lightly coat the sealing head seal components with FML-2 grease and slide the seal assembly onto the inlet end of the sealing head.
7. Lightly coat the outboard bore of the high pressure cylinder with FML-2 grease.
8. Clean and lubricate the cylinder threads with Pure Goop.
9. Apply Pure Goop to the sealing surface of the sealing head. Position the sealing head in the end cap. Hold the sealing head securely against the end cap and thread the end cap onto the cylinder.

If the sealing head begins to resist turning as the end cap threads onto the cylinder, tap the outboard end of the sealing head with a plastic hammer until the sealing head seats against the end of the cylinder.

**CAUTION**

Avoid hitting the end of the sealing head against the cylinder to prevent damage to the inlet check valve, seals and sealing surfaces.

Avoid rotating the sealing head relative to the cylinder to avoid premature seal leakage.

10. Turn the end cap until it bottoms out. Tighten the end cap with the spanner wrench and finish with a single, light tap on the wrench handle. **Do not** tighten further.
11. Lubricate the o-rings on the sealing head collar with FML-2 grease and install the collar.
12. Connect the high and low pressure water piping, following the procedure, High and Low Pressure Water Piping.
13. Start the machine in low pressure mode to flush air from the high pressure components and to check for obvious leaks. After 5-10 strokes, switch to high pressure operation and check for leaks.

If leaks are detected, turn the machine off and remedy the problem. When the problem has been remedied, repeat the start up procedure, moving from low to high pressure soon after the intensifier starts pumping water. There is no further need to flush air from the system.

High Pressure Cylinder Maintenance

The plunger seal area in the high pressure cylinder bore should be inspected and cleaned each time the high pressure seal assembly is replaced.

1. Clean the sealing area on the inside diameter of the high pressure cylinder and inspect the bore for rings, scratches, pits, residue or other potential leak paths.

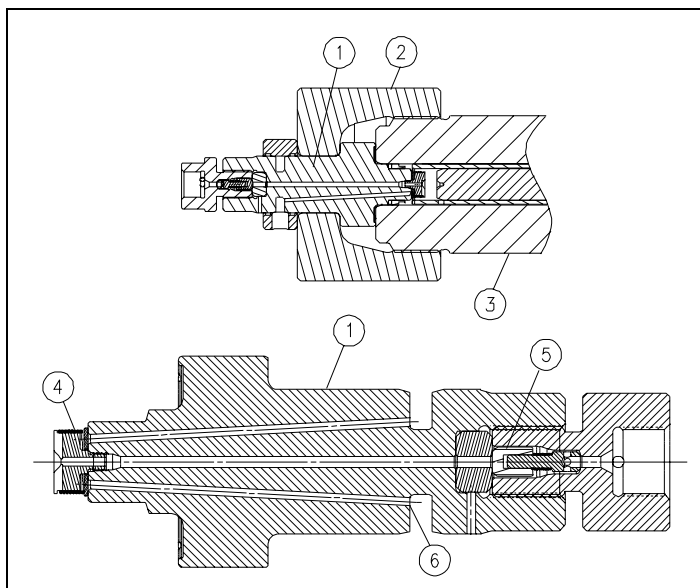
Seal material or residue can build up, forming a ring. Running a fingernail across the buildup will cause it to appear as a surface flaw. Grooves or ridges are typically seal debris buildup rather than marks on the inside diameter wall of the cylinder.

2. Polish the inside diameter of the cylinder where the seals will locate with 600-grit wet/dry sandpaper. Hold the sandpaper on the end of your finger and move in a cylindrical wiping motion. Polish in a circumferential motion only. Do not polish or drag the sandpaper along the length of the cylinder.
3. Clean the residue from the inside diameter of the cylinder and re-inspect for surface defects.

9.7 Sealing Head

The sealing head is sealed to the outboard end of the high pressure cylinder by the sealing head seal assembly. The inlet and discharge check valves in the sealing head ensure the low pressure and high pressure water only travels in the appropriate direction.

Figure 9-9: Sealing Head



- | | |
|--------------------------|-------------------------|
| 1 Sealing Head | 4 Inlet Check Valve |
| 2 Soft Seal End Cap | 5 Discharge Check Valve |
| 3 High Pressure Cylinder | 6 Inlet Water Groove |

High Pressure Discharge Check Valve

The high pressure discharge check valves require service when water leakage is present at the sealing head weep hole or when the sealing head and discharge gland are warm to the touch. The discharge check valve can be serviced with the sealing head either installed or removed from the high pressure cylinder.

1. Turn the machine off and observe the appropriate Lockout/Tagout procedures.

**WARNING**

Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before proceeding.

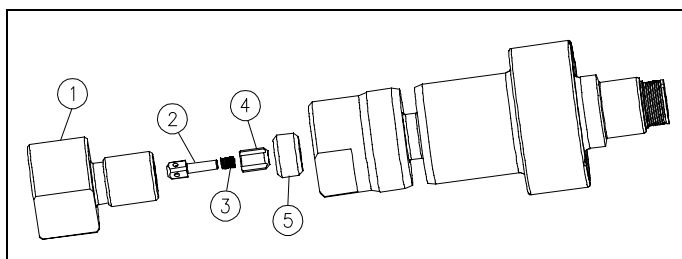
Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before proceeding.

2. Disconnect the high pressure water piping, following the procedure, High and Low Pressure Water Piping.
3. Use two wrenches to remove the gland nut. The poppet pin, spring and poppet check valve will normally remain in the gland nut when it is removed. Remove the components from the gland nut.
4. Use a magnet to remove the seat from the sealing head.
5. Inspect the poppet pin for wear and replace the pin if worn.
6. Inspect both faces of the seat for damage or cracking. A cracked or damaged seat must be replaced. The seat can be installed with either face toward the poppet valve. If one face is worn, but the opposite is not, the seat can be reversed, placing the new surface toward the poppet valve. A slight burr at the hole edge identifies the used side of the seat. If both faces are worn, the seat must be replaced.

NOTE

The seat, spring and poppet valve should be replaced as a set. If one component requires replacement, replace all components.

Figure 9-10: High Pressure Discharge Check Valve



- | | |
|----------------------|--------------------------------|
| 1 Gland Nut | 4 Discharge Poppet Check Valve |
| 2 Poppet Pin | 5 Seat |
| 3 Compression Spring | |

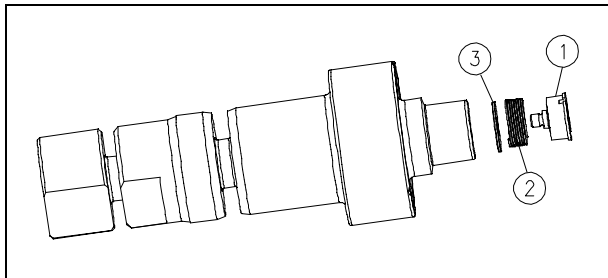
7. Apply a thin film of Pure Goop to the face of the seat opposite the poppet check valve and install the seat into the sealing head. If the existing seat is reused, install the seat with the new surface facing the poppet valve.
8. Install the poppet pin, spring and poppet valve into the gland nut.

9. Apply Pure Goop to the sealing face and the threads on the gland nut and thread the gland nut into the sealing head. Hand-tighten until there is a 0.20 inch (5 mm) gap between the gland nut and the sealing head. **No threads should show.** If the gap exceeds 0.20 inch (5 mm), the poppet or seat has slipped out of position. The parts must be removed, inspected and re-assembled.
10. Use a crowfoot/torque wrench combination and tighten the gland nut to the torque specifications in Table 9-1.

Low Pressure Inlet Check Valve

The need for inlet check valve service is indicated by unbalanced shifting or if the inlet ring is warm to the touch. The high pressure cylinder assembly components must be disassembled to service the inlet check valve. Follow the procedure, High Pressure Cylinder Assembly Removal. When the components have been removed, proceed with Step 1 below.

Figure 9-11: Low Pressure Inlet Check Valve



- | | |
|----------------------|----------------------------|
| 1 Poppet Retainer | 3 Inlet Poppet Check Valve |
| 2 Compression Spring | |

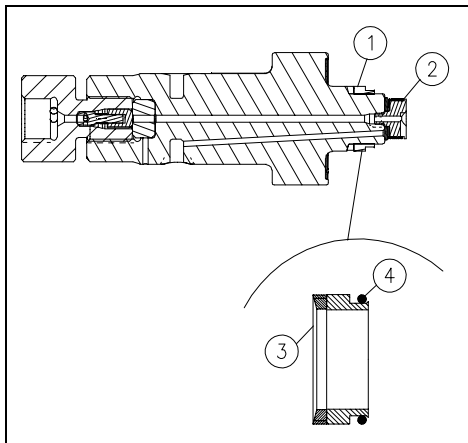
1. Use a 1/2-inch flat blade screwdriver to remove the poppet retainer from the sealing head.
2. Inspect the sealing head for scratches or wear on the sealing head seal contact surface, and on the inlet poppet valve contact surface. If defects are detected, the surfaces must be refinished. See the procedure, Sealing Head Maintenance.
3. Inspect both faces on the inlet poppet valve. The poppet valve can be installed with either face toward the sealing head. If one face is worn, but the opposite is not, the poppet can be reversed, placing the best surface toward the sealing head. If both faces are worn, the poppet valve must be replaced.
4. Spray Loctite 7649 on the threads of the poppet retainer and allow to dry. Assemble the spring and the inlet poppet valve on the poppet retainer. Apply a small amount of Loctite 242 to the poppet retainer threads only. **Do not** get any Loctite on the poppet or any other surfaces on the inlet check valve.
5. Use the flat blade screwdriver to tighten the poppet retainer. Tighten the poppet retainer to the torque specifications in Table 9-1.
6. Inspect the assembled unit to ensure the poppet moves freely, the spring is fully guided on the poppet retainer, the spring end is 90 degrees from the screwdriver slot on the retainer and the poppet retainer is seated against the sealing head.

Sealing Head Seal Assembly

Whenever maintenance requires the sealing head to be removed, the sealing head seal assembly must be replaced.

1. Prior to installing a new seal assembly, inspect and clean the seal surfaces on the sealing head and the high pressure cylinder bore. Inspect and clean the cylinder liner.
2. Install the cylinder liner.
3. Lightly coat the seal components with FML-2 grease and slide the seal assembly onto the inlet end of the sealing head as illustrated. The wedge ring chamfer must be installed against the chamfered shoulder of the sealing head and the o-ring must face the inlet check valve.

Figure 9-12: Sealing Head Seal Assembly



- | | |
|------------------------------|-----------------|
| 1 Sealing Head Seal Assembly | 3 Wedge Ring |
| 2 Inlet Check Valve | 4 Seal w/O-Ring |

Sealing Head Maintenance

The sealing head should be inspected for scratches, excessive sealing damage or erosion marking on the sealing head seal contact surface, and on the inlet poppet valve contact surface. The inlet water groove should be inspected for cracking. If defects are detected, the surfaces must be refinished. The sealing head can be returned to KMT Waterjet for refinishing.

1. Inspect the inlet poppet valve sealing surface for pits, scratches or jetting erosion. If necessary, refinish the surface.

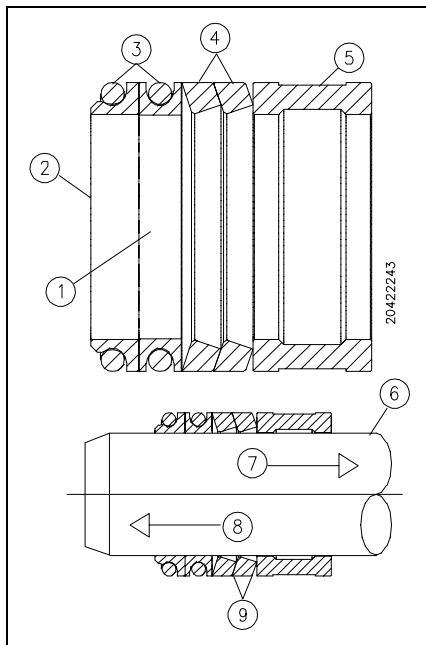
Place a piece of 1/4-1/2" thick plate glass, not window glass, on a sturdy table to provide an absolutely flat surface. Place a piece of 400-grit wet/dry sandpaper on the glass. Use even, deliberate strokes, rotating the sealing head approximately 10-15 degrees after each stroke. Polish the sealing head until it is flat and smooth. Be careful not to cause additional damage by tilting or tipping the part while polishing.

2. When the sealing head is flat and smooth, perform a final polish with 600-grit wet/dry sandpaper.

9.8 High Pressure Seal Assembly

The following procedure should be used to replace the high pressure seal assembly.

Figure 9-13: High Pressure Seal Assembly



- | | |
|--------------------|------------------|
| 1 U-Body Seal | Seal Orientation |
| 2 J5 Hyper Seal | 6 Plunger |
| 3 O-Ring | 7 Piston |
| 4 Backup Ring | 8 Sealing Head |
| 5 Packing Follower | 9 Red Surfaces |

Prior to removing electrical power or any high or low pressure piping, bring the hydraulic piston in the left or right stop position to facilitate maintenance. The plunger will extend in the selected direction, allowing full exposure when the unit is disassembled. Refer to Section 4, Operation.

1. Turn the machine off and observe the appropriate Lockout/Tagout procedures.



WARNING

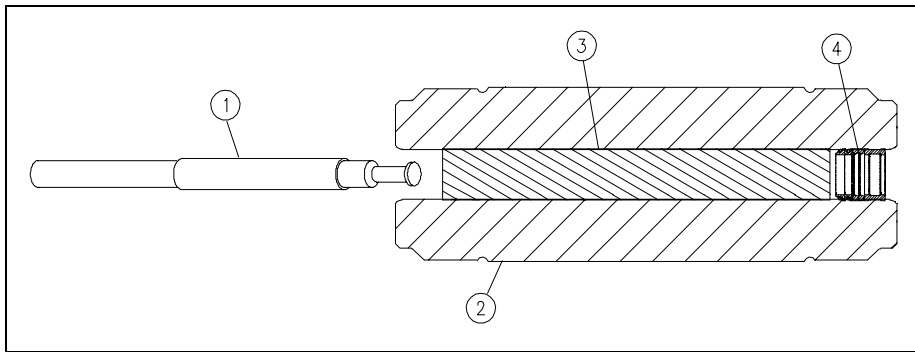
Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before proceeding.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before proceeding.

2. Disconnect the high and low pressure water piping, following the procedure, High and Low Pressure Water Piping.

3. Remove the high pressure cylinder assembly components, following the procedure, High Pressure Cylinder Assembly Removal.
4. Remove the high pressure seal assembly from the cylinder by inserting the seal removal tool into the cylinder and pushing the seal assembly out. Use caution to avoid scratching the cylinder bore.

Figure 9-14: High Pressure Seal Removal



- | | |
|--------------------------|-------------------------------|
| 1 Seal Removal Tool | 3 Cylinder Liner |
| 2 High Pressure Cylinder | 4 High Pressure Seal Assembly |

5. Remove the cylinder liner from the bore and inspect for possible heat or wear damage, or for debris. If cracks or brittleness are detected on the tabs on the ends of the liner, the liner must be replaced.
6. Feel approximately one inch into the cylinder bore for obvious ridges or grooves. If seal debris is present, follow the procedure, High Pressure Cylinder Maintenance.
7. Inspect the plunger surface for flaws. Rotate the plunger 360 degrees by hand while viewing light reflection on the surface to detect any dullness, streaks, pits or other defects. Run a fingernail perpendicular to the direction of the suspected flaws to determine the severity of defects. Depending on the seal life achieved with the removed seal assembly, make a judgment regarding plunger and/or cylinder replacement. If seal debris is present on the plunger, polish with 600-grit wet/dry sandpaper, using a radial motion.
8. Lightly coat the new seal components with FML-2 grease and install the new components on the plunger. Ensure the proper orientation of the backup rings as illustrated in Figure 9-13, High Pressure Seal Assembly.
9. Slide the cylinder liner over the plunger.
10. Install the high pressure cylinder into the hydraulic cylinder head, following the procedure, High Pressure Cylinder Assembly Installation.
11. Reconnect the high and low pressure water piping and turn the low pressure water supply on.

9.9 Hydraulic Seal Cartridge Replacement

The following procedure is used to remove and replace the hydraulic seal cartridge.

Prior to removing electrical power or any high or low pressure piping, bring the hydraulic piston in the left or right stop position to facilitate maintenance. The plunger will extend in the selected direction, allowing full exposure when the unit is disassembled. Refer to Section 4, Operation.

1. Turn the machine off and observe the appropriate Lockout/Tagout procedures.



WARNING

Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before proceeding.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before proceeding.

2. Disconnect the high and low pressure water piping, following the procedure, High and Low Pressure Water Piping.
3. Remove the proximity switch on the end of the hydraulic cylinder to be serviced. This will allow the hydraulic oil to drain back to the reservoir, minimizing oil spillage. It will take approximately five minutes for the oil to drain.
4. Remove the high pressure cylinder assembly components, following the procedure, High Pressure Cylinder Assembly Removal.
5. Use a flat screwdriver to remove the retaining ring from the hydraulic cylinder head.
6. Remove the bushing retainer flange and clean the surfaces, weep holes and grooves. Check the retainer flange for cracks.
7. Replace the proximity switch by positioning the o-ring spacer and the switch. Apply JL-M grease to the threads on the socket head screws and tighten, following the torque specifications in Table 9-1.

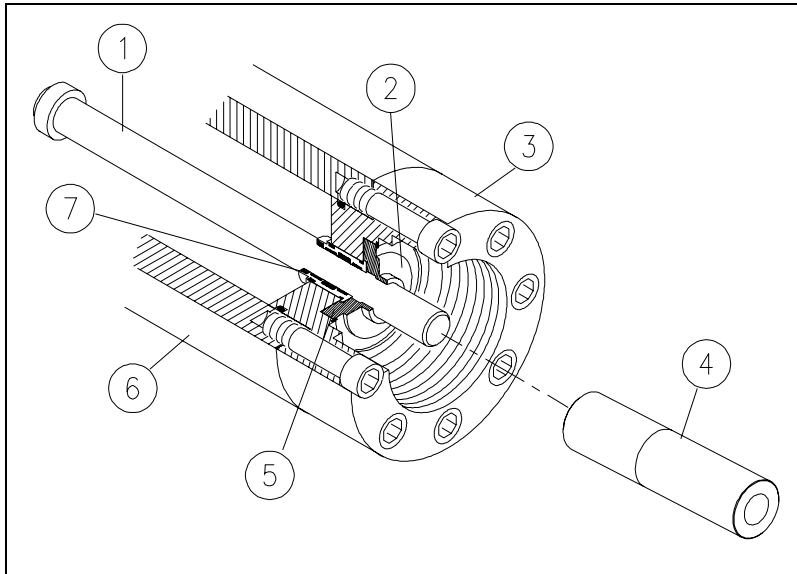


CAUTION

It is recommended that the proximity switch be reinstalled as soon as practical. Removal of the switch presents the potential of an oil spray hazard.

Ensure that the proximity switch is properly installed and secured prior to starting the machine. Failure to tighten the two hold down screws on each switch will result in the spray of hydraulic oil.

8. Thread the large end of the cartridge removal tool onto the hydraulic cartridge seal and pull the cartridge out, over the plunger.

Figure 9-15: Hydraulic Seal Cartridge Removal

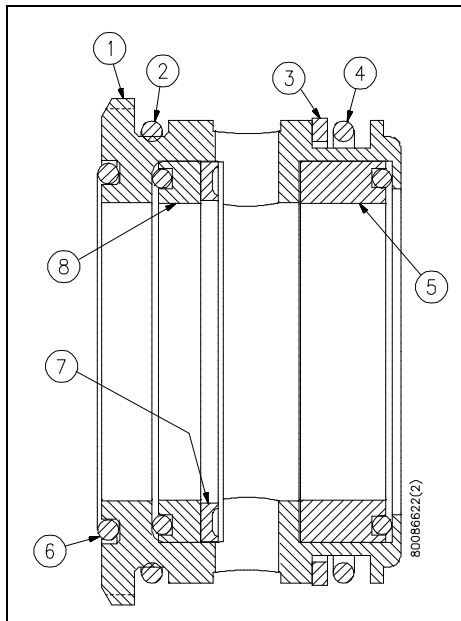
- | | |
|---------------------------|----------------------------|
| 1 Plunger | 5 Retaining Ring |
| 2 Bushing Retainer Flange | 6 Hydraulic Cylinder |
| 3 Hydraulic Cylinder Head | 7 Hydraulic Seal Cartridge |
| 4 Cartridge Removal Tool | |

Hydraulic Seal Cartridge

Seals in the hydraulic cartridge can be removed and replaced, or the complete cartridge can be replaced.

Use caution during the removal and installation of the seal components to avoid scratching the surface of the cartridge. The seal removal tool, a plastic or wooden dowel, or similar object can be used for seal removal. **Do not** use screwdrivers, wires or other metal objects that could damage the cartridge. To avoid damaging the new seals, the seal installation tool can be used for installation.

Figure 9-16: Hydraulic Seal Cartridge



- | | |
|----------------|-------------------------|
| 1 Seal Bushing | 5 Packing Ring w/O-Ring |
| 2 O-Ring | 6 O-Ring |
| 3 Backup Ring | 7 Backup Ring |
| 4 O-Ring | 8 U-Cup Packing Seal |

- Carefully remove the worn seals and o-rings from the cartridge by pushing them with a plastic or wooden dowel, or similar object. Remove the seals closest to the open ends first, and work toward the center.
- Inspect the seals for unusual wear, deformation or cuts. Note any unusual buildup of solid material or debris creating possible leak paths.
- Inspect the surface of the cartridge body for scratches, deformation, signs of metal-to-metal contact or other unusual wear. Carefully examine the surface of the grooves on the inside diameter. Note any scratches in the axial direction that could create a leak path.
- Apply FML-2 grease to the inside and outside diameter of the cartridge body, and to the individual seal components.
- Install the seals, starting in the center and working toward the ends. See Figure 9-16 for the proper orientation of the u-cup packing seal. If available, use the seal installation tool to install the u-cup packing seal. See Figure 9-23, Pneumatic Valve Seal Tools.
- Verify that the u-cup o-ring is properly positioned after installation.
- When the seal components are properly installed, apply FML-2 grease to the exposed surfaces of the seals and slide the hydraulic cartridge seal over the plunger, into the cavity of the hydraulic cylinder head.



8. Thoroughly clean the bushing retainer flange, including the cross-drilled weep holes. Install the retainer flange over the plunger.
9. Install the retaining ring, ensuring the retaining ring fully seats inside the groove in the hydraulic cylinder head.

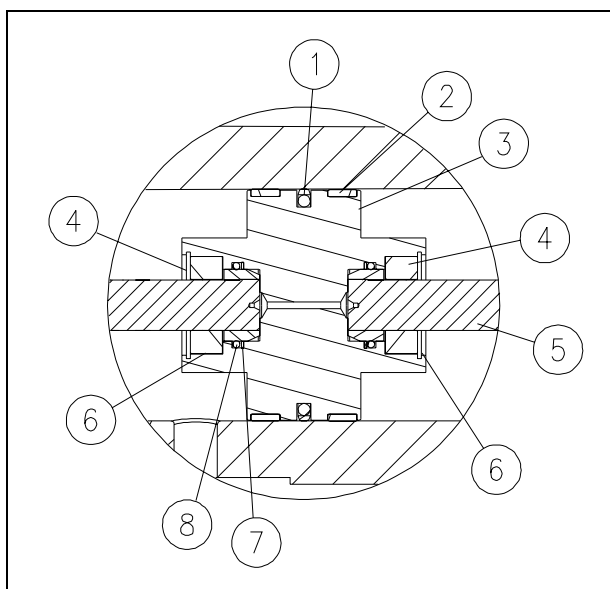
The o-rings on the hydraulic cartridge will take up clearance. Tap lightly on the bushing retainer flange with the cartridge removal tool to compress the o-rings enough to start the retaining ring in the groove. Use a flat blade screwdriver to push on the outer edge of the retainer flange while working one end of the retaining ring into the groove. The retainer flange should tilt or tip enough to allow the retaining ring to move into the groove. Continue working the ring into the groove while tilting the retainer flange until the ring is fully seated.

10. Install the high pressure cylinder into the hydraulic cylinder head, following the procedure, High Pressure Cylinder Assembly Installation.
11. Connect the high and low pressure water piping and turn the low pressure water supply on.

9.10 Hydraulic Piston and Plungers

Two bearing rings provide wear contact between the piston and the inside diameter of the hydraulic cylinder. On each end of the piston, a plunger retainer and retaining ring hold the plungers in position.

Figure 9-17: Hydraulic Piston Components



- | | |
|------------------------|------------------|
| 1 Piston Seal Assembly | 5 Plunger |
| 2 Bearing Ring | 6 Retaining Ring |
| 3 Ram Piston | 7 Backup Ring |
| 4 Plunger Retainer | 8 O-Ring |

Hydraulic Piston and Plunger Removal

The following procedure is used to remove the hydraulic piston and plungers. It is necessary to remove the components from both ends of the intensifier.

Prior to removing electrical power or any high or low pressure piping, bring the hydraulic piston in the left or right stop position to facilitate maintenance. The plunger will extend in the selected direction, allowing full exposure when the unit is disassembled. Refer to Section 4, Operation.

1. Turn the machine off and observe the appropriate Lockout/Tagout procedures.



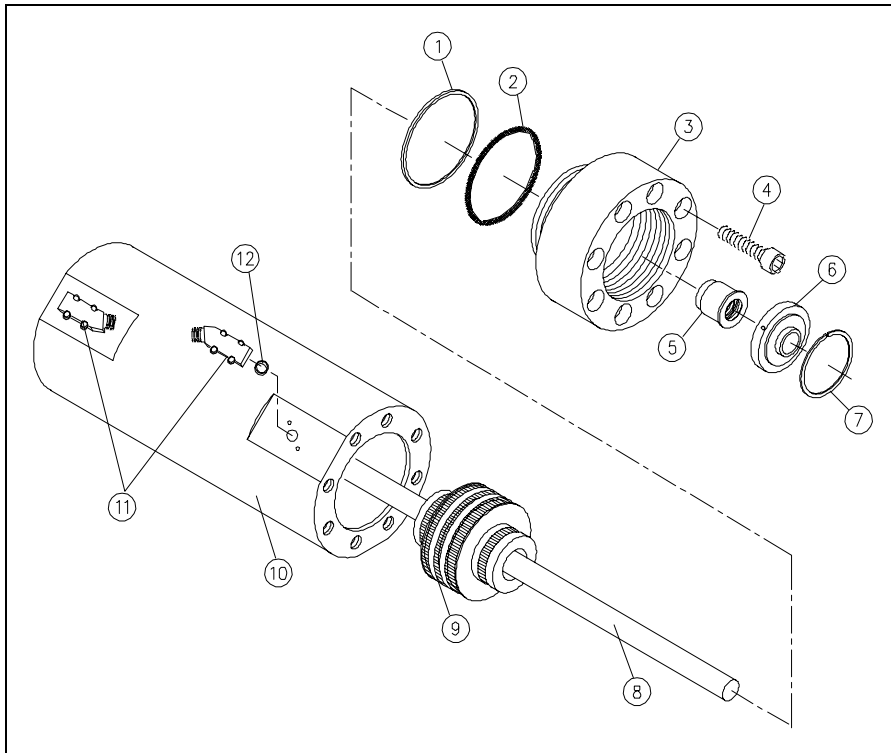
WARNING

Severe injury can result if the machine is not properly locked out. Observe electrical Lockout/Tagout procedures before proceeding.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before proceeding.

2. Disconnect the high and low pressure water piping from both ends of the intensifier, following the procedure, High and Low Pressure Water Piping.
3. Remove the high pressure cylinder assembly components on each end of the intensifier, following the procedure, High Pressure Cylinder Assembly Removal.

Figure 9-18: Hydraulic Piston Removal



- | | | |
|---------------------------|----------------------------|-----------------------|
| 1 O-Ring | 5 Hydraulic Seal Cartridge | 9 Hydraulic Piston |
| 2 Backup Ring | 6 Bushing Retainer Flange | 10 Hydraulic Cylinder |
| 3 Hydraulic Cylinder Head | 7 Retaining Ring | 11 Proximity Switch |
| 4 Socket Head Screw | 8 Plunger | 12 O-Ring Spacer |

4. Remove both of the proximity switches to prevent interference and to allow the hydraulic oil to drain back to the reservoir, minimizing oil spillage. It will take approximately five minutes for the oil to drain.
5. Remove the retaining rings, bushing retainer flanges and the hydraulic cartridge seals.
6. Loosen and remove the socket head screws in the hydraulic cylinder heads.
7. Remove the hydraulic cylinder heads with the o-rings and backup rings. The mounting flat for the proximity switch provides a small lip for loosening the cylinder head.
8. Grasp the plunger firmly and pull the piston out of the hydraulic cylinder.
9. Place the piston in a vice and remove the retaining ring on each end of the piston.

10. Pull each plunger to remove it from the piston. The plunger retainer will remain with the plunger when it is removed.
11. Remove the o-ring and the backup ring from each side of the piston.

Bearing Rings and Seal Assembly

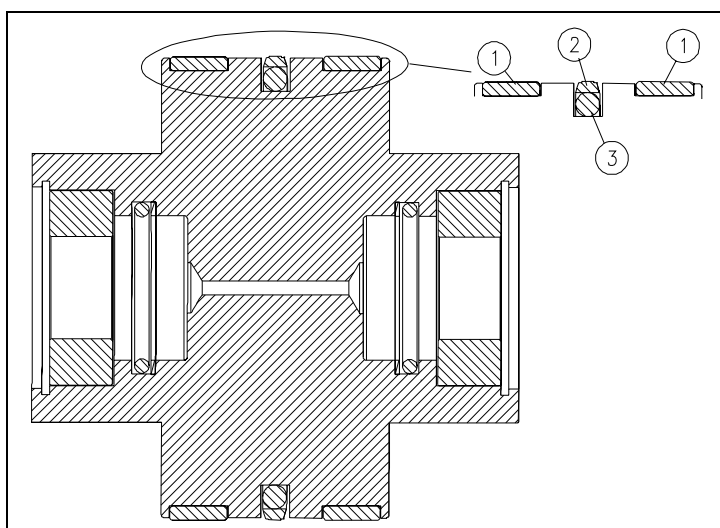
1. Use a smooth, dull-edged blade made from brass or similar soft metal material to remove the two bearing rings and the two-piece seal assembly.

NOTE

Do not scratch the surfaces of the piston seal groove. Scratches on the sides or bottom of the groove can result in hydraulic leaks.

2. Inspect the bottom of the seal grooves for marks, scratches and residue buildup. Clean and/or repair the groove surfaces as required.
3. Apply FML-2 grease to the new bearing rings and install the rings.
4. The piston seal assembly consists of a seal ring and an o-ring. Apply FML-2 grease to both rings. Use the smooth, dull-edged blade to install the o-ring, ensuring the ring is not twisted after installation. Slide the outer seal ring over the metal edges and ease it into position over the inner, o-ring.

Figure 9-19: Hydraulic Piston



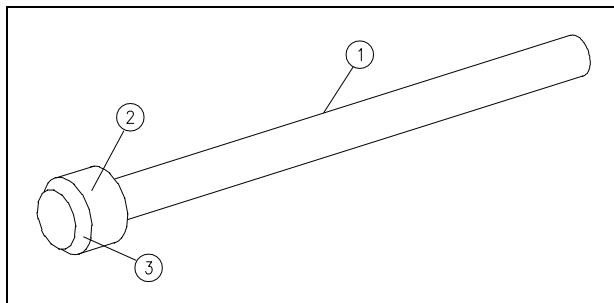
- | | |
|-------------------|----------------|
| 1 Bearing Ring | 3 Inner O-Ring |
| 2 Outer Seal Ring | |

Plunger Maintenance

Plunger surfaces can become streaked with longitudinal scratches or flaws, and discolored or dull in appearance. If any of these conditions become severe, the high pressure seal assembly and possibly the hydraulic cartridge seal will leak.

Accumulation of debris on the surface of the plunger can be removed by polishing in a radial direction with 600-grit sandpaper. However, plunger surface flaws usually cannot be repaired on site. The plunger can be returned to KMT Waterjet for reconditioning.

Figure 9-20: Plunger

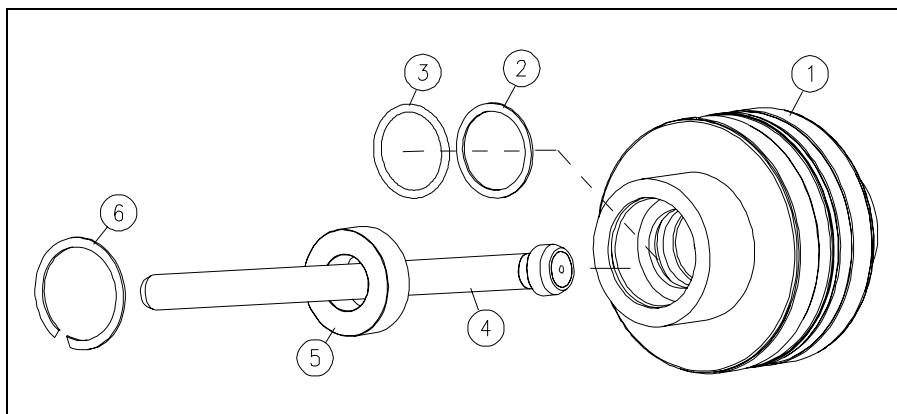


- | | |
|------------------|------------------|
| 1 Plunger | 3 Button Chamfer |
| 2 Plunger Button | |

Hydraulic Piston and Plunger Installation

1. Apply FML-2 grease to the new o-ring and backup rings. Install the backup ring and then the o-ring in the groove in the plunger socket.
2. Slide the plunger retainer onto the piston and push the plunger onto the plunger socket.
3. Make sure the retainer is properly positioned in the socket.
4. Install the retaining ring into the cavity of the plunger socket.

Figure 9-21: Hydraulic Piston Installation



- | | |
|--------------------|--------------------|
| 1 Hydraulic Piston | 4 Plunger |
| 2 Backup Ring | 5 Plunger Retainer |
| 3 O-Ring | 6 Retaining Ring |

5. Repeat steps 1-3 to install the second plunger.
6. Ensure that the hydraulic cylinder bore is free of grit or contamination.

7. Lubricate the bearing rings and seal assembly, and lightly lubricate 2-3 inches of the cylinder bore with FML-2 grease.
8. Install the piston and plungers into the hydraulic cylinder bore.
9. Verify that the o-rings and backup rings are properly positioned in the grooves on the hydraulic cylinder heads, and that they are sufficiently lubricated with FML-2 grease.
10. Position the cylinder heads in the end of the hydraulic cylinder. Apply JL-M grease to the threads on the socket head screws. Install the screws in the hydraulic cylinder heads and tighten, following the torque specifications in Table 9-1.
11. Verify that the plunger moves freely when handled. If it feels tight, there may be residue buildup in the pocket or the pocket depth may be insufficient.
12. Replace the hydraulic cartridge seals, bushing retainer flanges and retaining rings in the hydraulic cylinder heads.
13. Replace the proximity switches by positioning the o-ring spacers and the switches. Apply JL-M grease to the threads on the socket head screws and tighten, following the torque specifications in Table 9-1.

**CAUTION**

Ensure that the proximity switches are properly installed and secured prior to starting the motor. Failure to tighten the two hold down screws on each switch will result in the spray of hydraulic oil.

14. Install the high pressure cylinders into the hydraulic cylinder heads and install the remaining cylinder assembly components, following the procedure, High Pressure Cylinder Assembly Installation.
15. Connect the high and low pressure water piping. And turn the low pressure water supply on.

9.11 Hydraulic Cylinder Maintenance

The inside diameter surface of the hydraulic cylinder should be inspected for wear grooves and surface finish whenever the hydraulic cylinder heads are removed. Excessive grooving is indicative of piston seal wear.

9.12 High Pressure Attenuator

The high pressure attenuator is not serviceable at the customer level. KMT Waterjet Systems tests the seals in the attenuator at pressures exceeding normal operating pressure, making disassembly difficult. If the attenuator develops a high pressure water leak, it should be replaced.

9.13 High Pressure Dump Valve

The high pressure dump valve assembly includes a normally open high pressure water valve and a solenoid operated pneumatic actuator. The following procedure is recommended for servicing the high pressure dump valve. Failure to follow this procedure will cause damage to the stem, valve seat, or both.

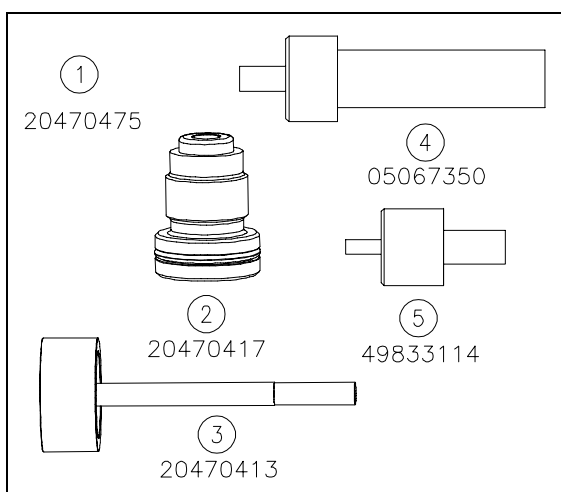


WARNING

The high pressure dump valve is a safety device designed to instantly release high pressure from the system. **Proper maintenance is imperative** to prevent potential personal injury.

Figure 9-22, Pneumatic Valve Seal Tools, illustrates the special tools recommended for this procedure.

Figure 9-22: Pneumatic Valve Seal Tools



- | | |
|-------------------------------------|------------------------------------|
| 1 Seal Tool Kit (20470475) | 4 Seal Positioning Tool (05067350) |
| 2 Seal Installation Tool (20470417) | NO/NC Pneumatic Valves |
| 3 Seal Push Tool (20470413) | 2-Port Pneumatic Dump Valves |
| | 5 Seal Positioning Tool (49833114) |
| | Quick Release Valves |
| | 3-Port Pneumatic Dump Valves |

Pneumatic Control Dump Valve

For reliable operation the valve seat, seal assembly, brass backup ring and stem shall always be replaced at the same time. The SST backup ring can be reused.

Before proceeding, disconnect and lockout the main power supply and the electrical enclosure; and ensure that all high pressure water and hydraulic pressure has been bled from the system.



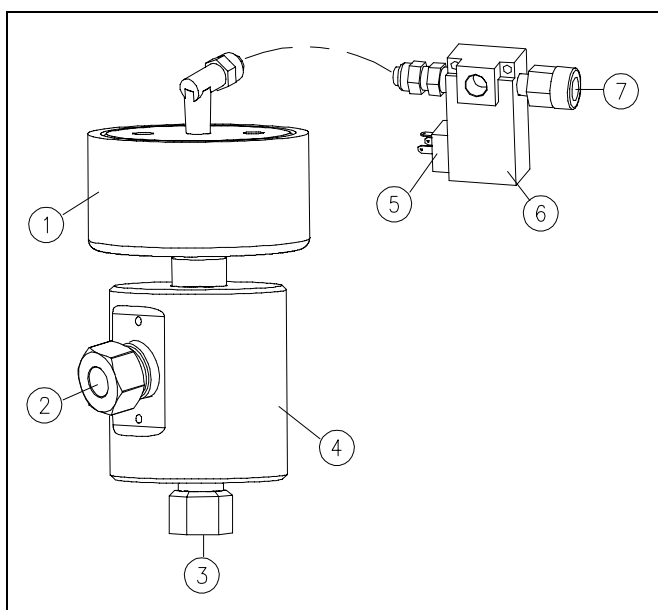
WARNING

Severe injury can result if the machine is not properly locked out. Observe electrical Lock Out/Tag Out procedures before proceeding.

Ensure all pressure is relieved or blocked from the hydraulic and high pressure circuits before proceeding.

1. Turn the air supply off.
2. Remove the air supply hose, and the electrical connection to the solenoid valve.

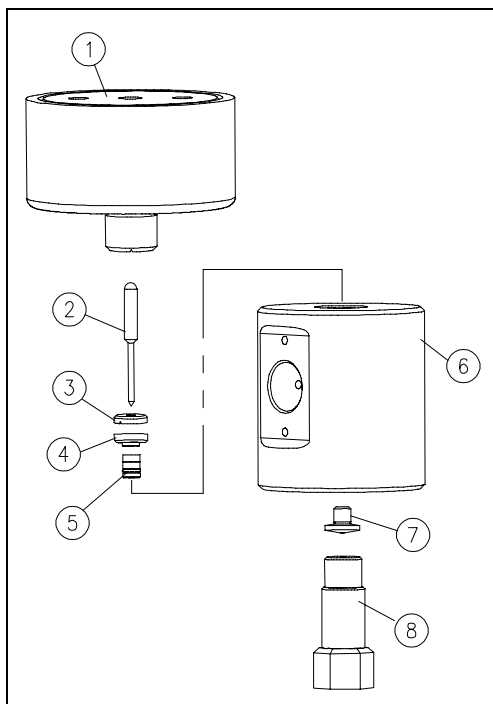
Figure 9-23: High Pressure Dump Valve



- | | |
|--------------------------------|-------------------|
| 1 Pneumatic Actuator | 5 Signal from PLC |
| 2 HP Water Out to Cutting Head | 6 Solenoid Valve |
| 3 Out to Drain | 7 Control Air In |
| 4 Valve Assembly | |

3. Loosen and remove the high pressure gland connections and the drain connection.
4. Remove the valve and actuator assembly from the machine.

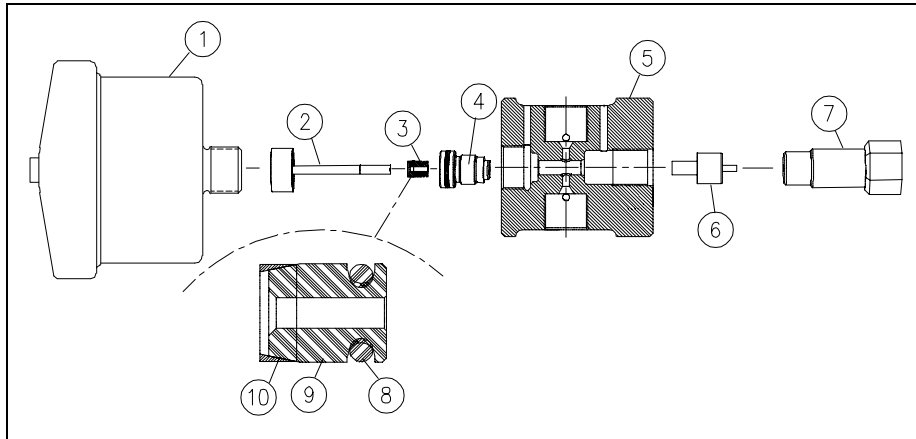
Figure 9-24: Dump Valve Components



- | | |
|----------------------|-------------------------|
| 1 Pneumatic Actuator | 5 Seal Assembly |
| 2 Stem | 6 Valve Body |
| 3 SST Backup Ring | 7 Valve Seat |
| 4 Brass Backup Ring | 8 High Pressure Adapter |

5. Loosen the cylinder head on the actuator. Unscrew and remove the actuator from the valve body.
6. Unscrew the high pressure adapter and remove the adapter and valve seat.
7. Remove the stem, SST backup ring and brass backup ring from the valve body.
8. Remove the seal assembly by pushing it with the seal push tool (P/N 20470413). **The assembly must be pushed out through the actuator port in the top of the valve body.**
9. **Discard** the stem, brass backup ring, seal assembly and valve seat.
10. Clean and inspect the valve body, being careful not to damage or scratch the bore.

Figure 9-25: Valve Seal Installation



- | | |
|--------------------------|-------------------------|
| 1 Pneumatic Actuator | 6 Seal Positioning Tool |
| 2 Seal Push Tool | 7 High Pressure Adapter |
| 3 Seal Assembly | 8 O-Ring |
| 4 Seal Installation Tool | 9 Seal |
| 5 Valve Body | 10 Bronze Wedge Ring |

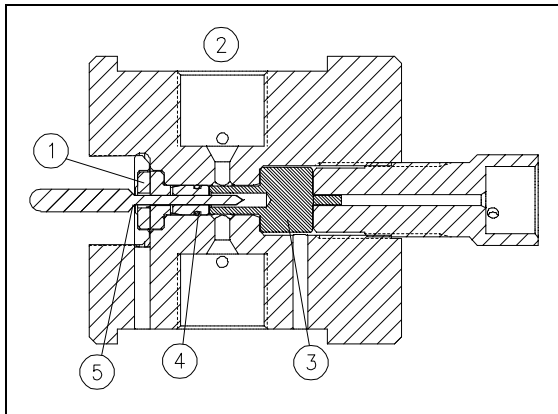
11. Place the seal positioning tool into the opposite end of the valve body as shown in Figure 9-25, Valve Seal Installation. Thread the high pressure adapter into the valve body until light contact is made with the positioning tool. **Tighten finger-tight only.**
12. Apply Pure Goop anti-seize compound to the threads on the seal installation tool. Screw the seal installation tool into the threads of the valve body. **Tighten finger-tight only.** See Figure 9-25, Valve Seal Installation.
13. Lubricate the new seal and o-ring with FML-2 food grade grease. Insert the seal, o-ring and bronze wedge ring into the seal installation tool, inserting the o-ring end of the seal first so the tapered end of the seal (wedge ring end) faces the actuator. The tapered end of the seal must face the actuator. See Figure 9-25, Valve Seal Installation.
14. Use the seal push tool to push the seal assembly into the bore of the valve body until the seal makes light contact with the seal positioning tool.
15. Remove the push tool and the installation tool from the valve body.
16. Install the existing SST backup ring and a new brass backup ring on a new stem. The vee groove on the SST backup ring must face toward the brass backup ring. The small OD of the brass backup ring must face toward the seal assembly. See Figure 9-24, Dump Valve Components.
17. Apply FML-2 grease to the tip of the stem and insert the stem with the backup rings into the top of the valve body so the stem enters the ID of the seal assembly. **Insert the stem until the chamfer on the stem is seated against the SST backup ring.** See Figure 9-26, Valve Stem Placement.



CAUTION

Do not push the o-ring on the seal assembly past the inlet port on the valve body.
This will damage the seal o-ring.

Figure 9-26: Valve Stem Placement



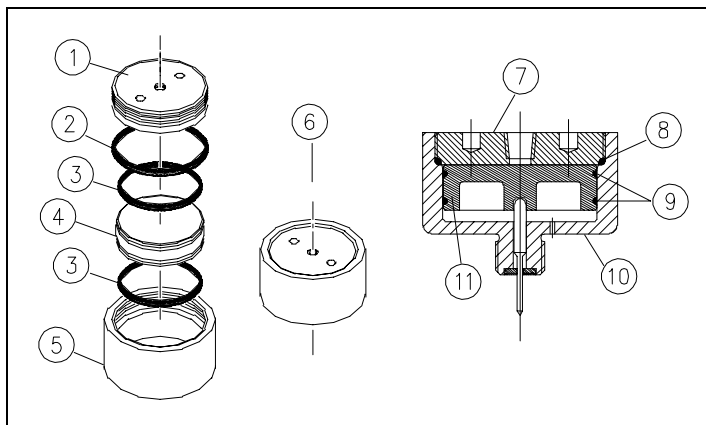
- | | |
|-------------------------|----------------|
| 1 SST Backup Ring | 4 Seal O-Ring |
| 2 Inlet Port | 5 Stem Chamfer |
| 3 Seal Positioning Tool | |

18. Remove the high pressure adapter and the seal positioning tool.
19. Apply Pure Goop anti-seize compound to the threads of the actuator and carefully thread it into the valve body, guiding the stem head into the hole in the actuator. Turn the actuator clockwise until resistance is felt. Reverse the actuator 1/4-turn, and give it a quick spin clockwise to seat it. **Hand-tighten only, 5 ft-lbs (7 Nm).**
20. Apply Pure Goop anti-seize compound to all surfaces, except the ID, of a new valve seat. Install the seat into the valve body, inserting the small OD first.
21. Apply anti-seize compound to the threads on the high pressure adapter. Install the adapter and torque to 25 ft-lbs (34 Nm).
22. Replace the 1/4-inch drain gland nut and collar and torque to 25 ft-lbs (34 Nm).
23. Apply anti-seize compound to the threads on the 3/8-inch high pressure gland fittings. Install the collar and the gland fittings and torque to 50 ft-lbs (68 Nm).
24. Install the air supply hose and the electrical connection to the solenoid valve. Turn the air pressure to the actuator on and test the valve for leaks and proper operation.

Pneumatic Actuator

The following procedure is used to service the pneumatic actuator.

Figure 9-27: Pneumatic Actuator



- | | |
|----------------------|-----------------------|
| 1 Cylinder Head | 7 Cylinder Head |
| 2 O-Ring | 8 O-Ring |
| 3 O-Ring | 9 O-Ring |
| 4 Piston | 10 Pneumatic Cylinder |
| 5 Pneumatic Cylinder | 11 Piston |
| 6 Control Air | |

1. Unscrew and remove the cylinder head using a strap wrench and a pin spanner. Remove the piston from the cylinder.



CAUTION

Do not install the pneumatic cylinder in a vise to remove the cylinder head. This may distort the body and seize the piston, preventing proper operation.

2. Remove the o-ring on the cylinder head. Apply FML-2 grease to a new o-ring and install.
3. Remove the two o-rings on the piston. Apply FML-2 grease to two new o-rings and install.
4. Install the piston in the pneumatic cylinder. Apply anti-seize compound to the threads on the cylinder head and screw it into the pneumatic cylinder.

9.14 Weep Holes

High pressure seals and connections fail gradually and begin leaking slowly. Weep holes are located at every threaded high pressure connection to provide a vent for internal leaks. Water or oil dripping from a weep hole indicates one or more internal components are beginning to fail.

Table 9-3 lists the location of the weep hole, the possible source of the leak and the corrective action required.

Table 9-3
Weep Holes
High Pressure Water System

Location	Indication	Comments
<i>Hydraulic Cylinder Head</i>		
Hydraulic oil leaking from the weep hole in the hydraulic cylinder head	Failed hydraulic cartridge seal	Replace the cartridge seal. If the leak persists, check the plunger for linear scratches or scoring.
Water leaking from the weep hole on the hydraulic cylinder head flange	Failed high pressure seal assembly	Replace the high pressure seal assembly.
	Damaged plunger	Check the plunger for longitudinal scratches or flaws. If detected, replace the plunger or return to KMT for evaluation.
	Seal material buildup on plunger	Polish the plunger surface following the procedure, Plunger Maintenance.
	Damaged high pressure cylinder	<p>Check for scratches, grooves or material buildup on the inside diameter of the cylinder. If detected, polish the bore following the procedure, High Pressure Cylinder Maintenance.</p> <p>Check the inside diameter of the cylinder for expansion where the high pressure seal assembly is located. If detected, replace the cylinder.</p>

Table 9-3
Weep Holes
High Pressure Water System

Location	Indication	Comments
<i>Sealing Head</i>		
Water leaking from the weep hole in the sealing head	Seat in the discharge check valve is not sealing properly	Make sure the gland nut is tightened to the proper torque specification.
		Inspect the seat, sealing head and gland nut for cracks.
	Internal crack in sealing head	Replace the sealing head. <i>A cracked sealing head can result in water leaking from the high pressure outlet passage to the low pressure inlet passages.</i> <i>The sealing head body can become extremely hot.</i>
	Improper torque on gland nut	Tighten the gland nut to the proper torque specification.
	Erosion or scratches on the contact surface of the sealing head, or on the gland nut where the seat makes contact	Polish the surfaces following the procedure, Sealing Head Maintenance.
Water leaking from the weep hole in the gland nut	High pressure piping gland nut is not tight and is not sealing properly	Tighten the gland nut to the proper torque specification.
	Improper high pressure piping connection	Check the number of exposed threads past the collar on the high pressure piping. Only 1-1/2 to 2-1/2 threads should be exposed.
		Check high pressure piping for damage, cracks or deformation.
		Inspect the gland nut for deformation of the threads.
	Damaged sealing head gland nut	Check the gland nut for cracks due to fatigue. If cracks are detected, replace the gland nut.

Table 9-3
Weep Holes
High Pressure Water System

Location	Indication	Comments
<i>Soft Seal End Cap</i>		
Water leaking from the weep holes in the soft seal end cap	Damaged high pressure cylinder	Check for scratches or grooves on the sealing surface. If detected, polish to remove following the procedure, High Pressure Cylinder Maintenance.
	External crack in sealing head	Replace the sealing head.
	Damaged sealing head	Check for scratches or grooves on the sealing surface of the sealing head. If detected, polish the surface following the procedure, Sealing Head Maintenance.
	Worn sealing head seal assembly	Replace seal assembly.



SECTION 10

TROUBLESHOOTING

10.1 Overview

The troubleshooting guide will help identify the probable cause of a system malfunction and assist in providing corrective action. The following symptoms are discussed in this section:

1. High oil temperature resulting in shutdown
2. Low oil level resulting in shutdown
3. Hydraulic pressure but no high pressure water pressure
4. No hydraulic oil pressure
5. Pump will not start
6. Console display and lights do not illuminate
7. Pump quits running
8. No control power
9. Red light on operator's console is flashing
10. Abnormal fluctuations in high pressure water signal
11. Hot surfaces on the high pressure cylinder components
12. Low cutting water supply pressure
13. Low cutting water pressure
14. Hydraulic oil leaking from the weep hole in the hydraulic cylinder head
15. Water leaking from the weep hole on the hydraulic cylinder head flange
16. Water leaking from the weep hole in the sealing head
17. Water leaking from the weep hole in the sealing head gland nut
18. Water leaking from the weep holes in the hard seal end cap
19. Outlet booster pump pressure is falling below 60 psi (4 bar)
20. Inlet water flow is poor and the filter housing is not filling completely
21. Water is leaking around the bleed valve on the filter head

10.2 Troubleshooting Guide

Listen to the machine and observe it in operation. Learn to recognize the normal sounds and operating conditions of the system. Carefully define the symptom of the problem. Locate the symptom on the troubleshooting guide that most closely corresponds to the problem.

If the symptoms in the guide do not correspond to the malfunction, or if the problem is not resolved by the recommended corrective action, contact the KMT Customer Service Department for assistance.

Jetline™ JL-1 Troubleshooting Guide

	Malfunction	Indication	Comments
1.	High oil temperature resulting in shutdown	Cooling water flow is restricted	Check cooling water source for proper temperature and flow rate. The water pressure delivered to the heat exchanger requires a minimum of 35 psi (2.4 bar) for flow through the exchanger.
		Water modulating valve is stuck open or closed, or is out of adjustment	Replace the valve.
			Adjust the valve.
		Scale build up in the heat exchanger has restricted the flow	The heat exchanger will need to be flushed or replaced.
2.	Low oil level resulting in shutdown		Check the level gauge.
			Check for hydraulic leaks.
			Check the level switch.
3.	Hydraulic pressure but no high pressure water pressure	Proximity switch failure	From the Maintenance Screen on the control panel, jog the intensifier left and right and verify that the red light comes on at both proximity switches.
		Coil failure on the directional control valve	Check the coils on the directional valve with a volt meter to verify if they are good or bad.
		PLC failure	If there are inputs from the proximity switches, but no outputs, contact the KMT Customer Service Department for a logic review and verification of PLC failure.

Jetline™ JL-1 Troubleshooting Guide

	Malfunction	Indication	Comments
4.	No hydraulic oil pressure	The high and low limit compensators on the hydraulic pump are blocked with debris and are not controlling the swashplate	Disassemble the compensators, clean and inspect the components following the maintenance procedure in Section 7, Hydraulic System.
		Incorrect motor rotation	Check the motor rotation.
		The flexible coupling has failed	Replace the flexible coupling.
5.	Pump will not start	Emergency stop button is depressed	Pull the E-STOP button out and press the RESET button.
			Check all remote E-STOP buttons.
		Output signal has been interrupted	Check the Q:0.0 relay.
		A protection fault has been activated	Check the display panel for fault messages.
		Motor overload relay has been tripped	Identify the source of the overload and remedy the problem. Reset the overload relay.
6.	Console display and lights do not illuminate	Main power is disconnected	Check the main power and verify that the main power disconnect is on.
		Control power is not available	Check the power supply circuit for a tripped breaker.
			Check the input and output of the 24 volt DC power supply.

Jetline™ JL-1 Troubleshooting Guide

	Malfunction	Indication	Comments
7.	Pump quits running	A system fault has been detected	Check the display panel for fault messages.
		Electrical power has been interrupted	Check the power supply circuit for a tripped breaker.
			Check the input and output of the 24 volt DC power supply.
			Verify that power is available at the main power source.
			Check for a tripped main circuit breaker.
			Check the Q:0.0 relay.
		Motor overload relay has been tripped	Identify the source of the overload and remedy the problem. Reset the overload relay.
8.	No control power	Circuit breaker has been tripped	Check the input and output of all circuit breakers.
		Power supply fault	Check the input and output voltages at the power supply.
		Emergency stop button is depressed	Pull the E-STOP button out.
			Check all remote E-STOP buttons.
		Master control relay is not energized	Verify that the contactor coil is pulling in on the master control relay.
		Contact set failure on the master control relay	Verify that the contact sets on the master control relay are changing states when the relay is energized.

Jetline™ JL-1 Troubleshooting Guide

	Malfunction	Indication	Comments
9.	Red light on operator's console is flashing	An alarm condition has occurred	<p>Check the display panel for fault messages.</p> <p><i>Refer to Section 4, Operation, for additional information regarding warning and alarm conditions and recovery procedures.</i></p>
10.	Abnormal fluctuations in high pressure water signal	Large, worn or damaged orifice	Make sure the orifice does not exceed the capacity of the pump.
			Make sure the orifice is in good working condition. Verify that the jewel is installed in the orifice mount.
		Check valve leakage	Inspect the discharge check valves in the sealing heads.
			Inspect the inlet check valves in the sealing heads.
		Seal leakage	Inspect the high pressure seal on the plunger.
			Inspect the sealing head seal assembly.
		Hydraulic control malfunction	Check the operation of the hydraulic relief valve.
			Verify that the directional control valve is shifting properly.
			Check the operation of the proximity switches.

Jetline™ JL-1 Troubleshooting Guide

	Malfunction	Indication	Comments
11.	Hot surfaces on the high pressure cylinder components	Leaking discharge check valve, hot sealing head body and discharge gland	Inspect the condition of the seat, poppet valve, spring, poppet pin and sealing head surface on the discharge end of the sealing heads.
		Leaking inlet check valve, hot inlet ring	Inspect the condition of the poppet valve, poppet retainer and the spring on the inlet end of the sealing heads.
		Damaged sealing head	Check the sealing head for cracks.
		Damaged high pressure cylinder	Check the high pressure cylinder for cracks.
12.	Low cutting water supply pressure	Restricted water supply	Check cutting water supply flow and pressure.
		Clogged water filter	Check the condition of the low pressure water filter and replace the filter element if necessary.
		Trapped air	Bleed the air from the cutting water plumbing.
13.	Low cutting water pressure	Low hydraulic pressure setting	If operating in low pressure, switch to high pressure operation and check the hydraulic pressure setting.
			Clean the high pressure adjustment valve.
			Clean the compensators on the hydraulic pump.
		Collapsed element in the high pressure line filter	Check the element in the high pressure line filter.
14.	Hydraulic oil leaking from the weep hole in the hydraulic cylinder head	Failed hydraulic cartridge seal	Replace the cartridge seal. If the leak persists, check the plunger for linear scratches or scoring.

Jetline™ JL-1 Troubleshooting Guide

	Malfunction	Indication	Comments
15.	Water leaking from the weep hole on the hydraulic cylinder head flange	Failed high pressure seal assembly	Replace the high pressure seal assembly.
		Damaged plunger	Check the plunger for longitudinal scratches or flaws. If detected, replace the plunger or return to KMT Waterjet for evaluation and rework.
		Seal material buildup on plunger	Polish the plunger surface following the procedure, Plunger Maintenance, detailed in Section 9, High Pressure Water System.
		Damaged high pressure cylinder	Check for scratches, grooves or material buildup on the inside diameter of the cylinder. If detected, polish the bore following the procedure, High Pressure Cylinder Maintenance, detailed in Section 9, High Pressure Water System.
			Check the inside diameter of the cylinder for expansion where the high pressure seal assembly is located. If detected, replace the cylinder.
16.	Water leaking from the weep hole in the sealing head	Seat in the discharge check valve is not sealing properly	Make sure the gland nut is tightened to the proper torque specification.
			Inspect the seat, sealing head and gland nut for scratches, erosion or cracks.
		Improper torque on gland nut	Tighten the gland nut to the proper torque specification.
		Erosion or scratches on the contact surface of the sealing head, or on the gland nut where the seat makes contact	Polish the surfaces following the procedure, Sealing Head Maintenance, detailed in Section 9, High Pressure Water System.

Jetline™ JL-1 Troubleshooting Guide

	Malfunction	Indication	Comments
17.	Water leaking from the weep hole in the sealing head gland nut	High pressure piping gland nut is not tight and is not sealing properly	Tighten the gland nut to the proper torque specification.
		Improper high pressure piping connection	Check the number of exposed threads past the collar on the high pressure piping. Only 1-1/2 to 2-1/2 threads should be exposed.
			Check high pressure piping for damage, cracks or deformation.
			Inspect the gland nut for deformation of the threads.
		Damaged sealing head gland nut	Check the gland nut for cracks due to fatigue. If cracks are detected, replace the gland nut.
18.	Water leaking from the weep holes in the soft seal end cap	Worn sealing head seal assembly	Replace seal assembly.
		Damaged high pressure cylinder	Check for scratches or grooves on the sealing surface. If detected, polish to remove following the procedure, High Pressure Cylinder Maintenance, detailed in Section 9, High Pressure Water System.
			Replace the high pressure cylinder.
		External crack in sealing head	Replace the sealing head.
		Damaged sealing head	Check for scratches or grooves on the sealing surface of the sealing head. If detected, polish the surface following the procedure, Sealing Head Maintenance, detailed in Section 9, High Pressure Water System.

Jetline™ JL-1 Troubleshooting Guide

	Malfunction	Indication	Comments
19.	Outlet booster pump pressure is falling below 60 psi (4 bar)	Booster pump needs to be adjusted or replaced	Booster pump should be adjusted to 120 psi (8 bar) when deadheaded.
		Inlet water pressure is low	
		Filter element is dirty and needs to be replaced	
20.	Inlet water flow is poor and the filter housing is not filling completely	Pipe sizing for inlet cutting water should be checked for pressure and flow	Cutting water supply will be lacking capacity or flow.
21.	Water is leaking around the bleed valve on the filter head	O-ring that closes the passage has deteriorated	A small o-ring under the valve can deteriorate causing the passage to remain open. The o-ring can be replaced by removing the screw and spring on the underneath side.



SECTION 11

SPECIFICATIONS

11.1 Overview

Comprehensive listings of specifications for the Jetline™ series are provided in this section.

Table 11-1
Jetline™ JL-1

Model	Motor Horsepower Rating	
	HP	Kw
JL-1 30	30	22
JL-1 50	50	37

11.2 Installation Specifications

Environment

Installation location	Indoors
Air borne dust/contaminants	Minimal
Ambient temperature	
Minimum storage	36° F (2° C)
Minimum operating	40° F (5° C)
Maximum operating	104° F (40° C)
Maximum relative humidity* (at maximum operating temperature)	95%

***Note:** When the relative humidity is above 50%, the oil in the reservoir should be checked frequently for water content.

Sound Level

Sound level with optional side panels	75.0 [dB(A)]
---------------------------------------	--------------

Equipment Dimensions and Weights

	Length	Width	Height	Weight
JL-1 30	78.98" (2,006 mm)	36.00" (914 mm)	46.58" (1,183 mm)	2,450 lbs (1,111 kg)
JL-1 50	78.98" (2,006 mm)	36.00" (914 mm)	46.58" (1,183 mm)	2,650 lbs (1,202 kg)

Service Connections

		Connection	Height
A	Drain	1/2" BSPT	12.51" (318 mm)
B	Cutting Water In	1/2" BSPT	16.26" (413 mm)
C	Cooling Water In	1/2" BSPT	20.01" (508 mm)
D	Cooling Water Out	1/2" BSPT	23.76" (604 mm)
E	Contaminated Waste Drain	1/2" BSPT	28.76" (730 mm)
F	Cutting Water Out	9/16" HP	36.26" (921 mm)
G	Plant Air In	1/4" BSPT	40.26" (1,023 mm)

Plant Air

The facility compressed air connection should provide clean, dry air regulated to 85 psi (5.9 bar). Air usage is minimal, normally less than 1 scf/m.

The following table provides specifications for each ISO air quality classification. KMT recommends adherence to Quality Class 4.

Table 11-2
ISO Air Quality Classifications

ISO Quality Class	Maximum Particle Size (microns)	Maximum Pressure Dew Point (water @ 100 psi)	Maximum Oil Content (Mg/m ³)
1	0.1	-94° F (-60° C)	0.01
2	1	-40° F (-40° C)	0.1
3	5	-4° F (-20° C)	1
4	15	+38° F (+3° C)	5
5	40	+45° F (+7° C)	25
6	--	+50° F (+10° C)	--

11.3 Water Specifications

Cutting Water Supply (Low Pressure Water System)

	JL-1 30	JL-1 50
Maximum required inlet water flow	2.5 gpm (9.5 L/min)	4.0 gpm (15.1 L/min)
Minimum inlet water pressure	35 psi (2.4 bar) flowing	
Maximum inlet water pressure	80 psi (5.5 bar)	
Maximum booster outlet water pressure	120 psi (8.3 bar)	
Booster pump factory set inlet pressure	58 psi (4 bar)	
Booster pump factory set outlet pressure	120 psi (8.3 bar)	
Optimum inlet water temperature	65° F (18° C)	
Maximum inlet water temperature	85° F (29° C)	
Low inlet water pressure	30 psi (2 bar)	
Low booster pressure	60 psi (4 bar)	

Recirculation System

	JL-1 30	JL-1 50
Maximum consumption at 75° F (24° C)	1.5 gpm (5.7 L/min)	3.0 gpm (11.4 L/min)
Total heat rejection	5.3 HP (4.0 kW)	8.6 HP (6.4 kW)
Reservoir capacity	40 gal (151 L)	
Low oil level shutdown	30 gal (114 L)	
Minimum operating oil temperature	60° F (15° C)	
Optimum operating oil temperature	115° F (46° C)	
Hot oil shutdown (maximum operating oil temperature)	145° F (63° C)	
Minimum inlet cooling water pressure	35 psi (2.4 bar)	
Maximum inlet cooling water pressure	100 psi (6.9 bar)	
Oil filtration rating (Beta filtration rating)	B ₇ ≥1000*	
Fluid cleanliness rating (ISO fluid cleanliness rating))	17/14**	
Nominal recirculation pressure	30 psi (2 bar)	

Recommended oil type

General service

Mobil #DTE Heavy Medium, No.
021029

Conoco HydroclearTM multi-purpose
R&O

Food service

Fuchs/Geralyn AW68 Food Grade Oil

* **Note:** For each particle per milliliter downstream of the filter greater than 7 microns, there are 1000 particles per milliliter larger than 7 microns upstream of the filter.

Recirculation System

****Note:** Indicates ISO 4406 range numbers for maximum permissible number of particles per milliliter, greater than 5 and 15 microns.

17	<1,300 particles per milliliter, >5 microns
14	<160 particles per milliliter, >15 microns

Water Quality Standards

The quality of the inlet cutting water supply is one of the most important factors affecting component life and performance. Water treatment requirements can be determined by a water analysis.

The cutting water supply must meet the following standards. A high concentration of dissolved solids, especially calcium, silica and chlorides will affect high pressure component life.

Table 11-3
Water Quality Standards

Constituent (mg/l)	Minimum Requirement	Better	Best
Alkalinity	50	25	10
Calcium	25	5	0.5
Chloride	100	15	1
Free Chlorine	1	1	0.05
Iron	0.2	0.1	0.01
Magnesium as Mg	0.5	0.1	0.1
Manganese as Mn	0.1	0.1	0.1
Nitrate	25	25	10
Silica	15	10	1
Sodium	50	10	1
Sulfate	25	25	1
TDS*	200	100	35**
Total Hardness	25	10	1
pH	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity (NTU)	5	5	1

* **Note:** Total dissolved solids

Table 11-3
Water Quality Standards

Constituent (mg/l)	Minimum Requirement	Better	Best
**Note: Do not reduce the TDS beyond this amount or the water will be too aggressive.			

Table 11-4
Water Impurities

Constituent	Chemical Formula	Comments
Alkalinity	Bicarbonate (HCO_3) Carbonate (CO_3) Hydrate (OH), expressed as CaCO_3	Acid neutralizing capacity of water. Foaming and carryover of solids, causes embrittlement of steel, can produce CO_2 , a source of corrosion.
Calcium	Ca	When dissolved makes water hard; contributes to the formation of scale.
Chloride	Cl	Adds to solid content and increases corrosive character of water; in relative percentage presence with oxygen induces stress corrosion cracking.
Free Chlorine	Cl_2	Oxidizing agent; can attack elastomeric seals and damage reverse osmosis (RO) membranes.
Iron	Fe^{++} (ferrous) Fe^{+++} (ferric)	Discolors water or precipitation; source of scale and erosion.
Magnesium as Mg		When dissolved makes water hard; contributes to the formation of scale.
Manganese as Mn	Mn^{++}	Discolors water or precipitation; source of scale and erosion.
Nitrate	NO_3	Adds to solid content; effect is not generally significant industrially.
Silica	SiO_2	Causes scale
Sodium	Na	Found naturally; introduced to water in the ion exchange water softening process.
Sulfate	SO_4	Adds to solid content; combines with calcium to form calcium sulfate scale.
TDS		Measure of the total amount of dissolved matter in water.
Total Hardness	CaCO_3	Sum of all hardness constituents in water; typically expressed as their equivalent concentration of calcium carbonate; primarily due to calcium and magnesium in solution, but may include small amounts of metal. Carbonate hardness is usually due to magnesium and calcium bicarbonate; non-carbonate hardness is due to sulfates and chlorides.

Table 11-4
Water Impurities

Constituent	Chemical Formula	Comments
pH		Intensity of the acidic or alkaline solids in water; pH scale runs from 0, highly acidic, to 14, highly alkaline; with 7 being neutral.

11.4 Electrical Specifications

Electrical System

Motor type	TEFC (Totally Enclosed Fan Cooled)
Controls	
Voltage	24 volts DC
Power supply	5 amps DC

Ampacity and Power Voltage Requirements

Power Voltage	Motor Horsepower	Full Load Amps	Circuit Breaker Amps
208/3/60	30	80	100
230/3/60	30	76	100
380/3/50	30	44	60
400/3/50	30	43	60
415/3/50	30	43	60
460/3/60	30	38	50
575/3/60	30	32	40
200/3/50-60	50	132	175
208/3/50-60	50	128	175
240/3/60	50	112	175
380/3/50	50	69	100
400/3/50	50	66	100
415/3/50	50	64	100
480/3/60	50	56	80
575/3/60	50	47	80

11.5 Hydraulic and High Pressure Water System Specifications

Hydraulic System

Maximum operating pressure	2,750 psi (190 bar)
Main system relief valve	3,408 psi (235 bar)

High Pressure Water System

	JL-1 30	JL-1 50
Maximum flow rate		
55,000 psi (3,792 bar)	0.60 gpm (2.3 L/min)	1.0 gpm (3.8 L/min)
Plunger diameter	0.875" (22 mm)	
Piston diameter	4.03" (102.4 mm)	
Intensification ratio	20:1	
Minimum outlet pressure	6,000 psi (414 bar)	
Maximum outlet pressure	55,000 psi (3,792 bar)	

Pneumatic Control Valve

Maximum water pressure	60,000 psi (4,137 bar)
Regulated air pressure	85 psi (5.9 bar)
Maximum flow rate	1.0 cfm (0.028) m ³ /min

Orifice Capacity

The following tables provide horsepower requirements for some of the more popular orifices.

Table 11-5
Single Orifice Diameter

Model	Motor Horsepower Rating		Maximum Operating Pressure	Maximum Single Orifice Diameter (at full pressure)
	HP	Kw		
JL-1 30	30	22	55,000 psi (3,792 bar)	0.011 inch (0.28 mm)
JL-1 50	50	37	55,000 psi (3,792 bar)	0.014 inch (0.36 mm)

Table 11-6
Horsepower Requirements

Orifice Size inches (mm)	45,000 psi (3,103 bar)	50,000 psi (3,447 bar)	55,000 psi (3,792 bar)
0.003 (0.076)	1.7	2.0	2.3
0.004 (0.102)	3.0	3.5	4.0
0.005 (0.127)	4.6	5.4	6.2
0.006 (0.152)	6.7	7.8	9.0
0.007 (0.178)	9.1	10.6	12.2
0.008 (0.203)	11.8	13.9	16.0
0.009 (0.229)	15.0	17.5	20.2
0.010 (0.254)	18.5	21.6	25.0
0.011 (0.279)	22.4	26.2	30.2
0.012 (0.305)	26.6	31.2	36.0
0.013 (0.330)	31.2	36.6	42.2
0.014 (0.356)	36.2	42.4	48.9
0.015 (0.381)	41.6	48.7	56.2
0.016 (0.406)	47.3	55.4	63.9

The horsepower requirements for operating multiple orifices are determined by adding the requirements in Table 11-6 for each orifice. Examples are shown below.

Orifice Size inches (mm)	Number of Orifices	Operating Pressure	Calculation	Total Horsepower
0.005 (0.127)	3	55,000	3 x 6.2	18.6
0.012 (0.305) 0.009 (0.229)	1 1	50,000	31.2 + 17.5	48.7

Torque Specifications

Measurements are made with lubricated components and a certified calibrated torque wrench. Inconsistencies in wrench settings, lubrication and technique may not produce a leak free seal. If leakage occurs, the torque can be increased to seal the components. However, **do not exceed the recommended torque value by more than 15 percent**. If leakage persists, there is a component problem.



WARNING

Excessive torque can cause component damage or failure, resulting in potential hazards to equipment and personnel.

Torque Specifications**Hydraulic Cylinder Head**

Socket Head Screws

8 (14M) each

Torque

75-80 ft-lbs (102-108 Nm)

Hex Key

M12

Proximity Switch

Socket Head Screws

2 (M6) each

Torque

140-160 in-lbs (16-18 Nm)

Hex Key

M5

Intensifier Mount

Socket Head Screws

4 (M10) each

Torque

60-65 ft-lbs (80-88 Nm)

Hex Key

M8

Sealing Head

Discharge Gland Nut

130 ft-lbs (176 Nm)

Poppet Retainer

25-30 in-lbs (2.8-3.4 Nm)

Pneumatic Control Valve

3/8-inch HP Inlet Gland Nut

50 ft-lbs (68 Nm)

1/4-inch Outlet to Drain

25 ft-lbs (34 Nm)

Pneumatic Actuator

5 ft-lbs (7 Nm)

HP Adapter

25 ft-lbs (34 Nm)

High Pressure Fittings

1/4-inch Gland Nut

25 ft-lb (34 Nm)

3/8-inch Gland Nut

50 ft-lb (68 Nm)

9/16-inch Gland Nut

110 ft-lb (149 Nm)



SECTION 12

PARTS LIST

12.1 Overview

This section contains a comprehensive list of all standard and optional parts for the Jetline™ JL-1 50. To facilitate the ordering of replacement parts, item numbers in each table correspond to the identifying numbers in the accompanying figures.

Use the following information to contact the Customer Service Department at KMT Waterjet Systems.

USA

Customer Service Department
KMT Waterjet Systems
PO Box 231
635 West 12th Street
Baxter Springs, KS 66713-0231
USA

Phone (800) 826-9274
Fax (620) 856-2242
Email wj.service@kmtwaterjet.com
Email wj.parts@kmtwaterjet.com

Europe

Spare Parts Manager
KMT Waterjet Systems GmbH
Wasserstrahl Schneidetechnik
Auf der Laukert 11
D-61231 Bad Nauheim
Germany

Phone +49-6032-997-119
Fax +49-6032-997-271
Email order.spares@kmt-waterjet.com



12.2 Index

Part lists are arranged in the following sequence:

Parts List Index

Table	Description	Part Number	Page	Table	Description	Part Number	Page
12-1	JL-1 50 Intensifier Unit		12-3	12-10	Pump/Manifold Assembly	20478196	12-19
12-2	Intensifier Assembly	20460873	12-5	12-11	Hydraulic Hose Connections	20477268	12-21
12-3	Hydraulic Cartridge Seal	80086622	12-7	12-12	Reservoir Assembly	20477035	12-23
12-4	Sealing Head Assembly	05116769	12-8	12-13	Bulkhead Pipe Assembly	20477264	12-25
12-5	Pneumatic Valve/Actuator Assembly	20427739	12-9	12-14	Electrical Assembly	20477742	12-27
12-6	Hydraulic Piston Assembly	72112358	12-11	12-15	Electrical Configuration	20477068	12-29
12-7	High Pressure Water Assembly	20476916	12-13				
12-8	Low Pressure Water Filter	20454810	12-15				
12-9	Hydraulic Power Package	20476908	12-17				



Table 12-1
JL-1 50 Intensifier Unit

Item	Part Number	Description	Quantity
1	20453979	Electrical Enclosure	1
2	10064715	Lock Washer, M10	4
3	49883580	Flat Washer, M10	4
4	20476974	Frame Assembly	1
5	80070931	Nameplate	1
6	10070175	Hex Nut, M10	4
7	20476954	Decal Package	1

Figure 12-1: JL-1 50 Intensifier Unit

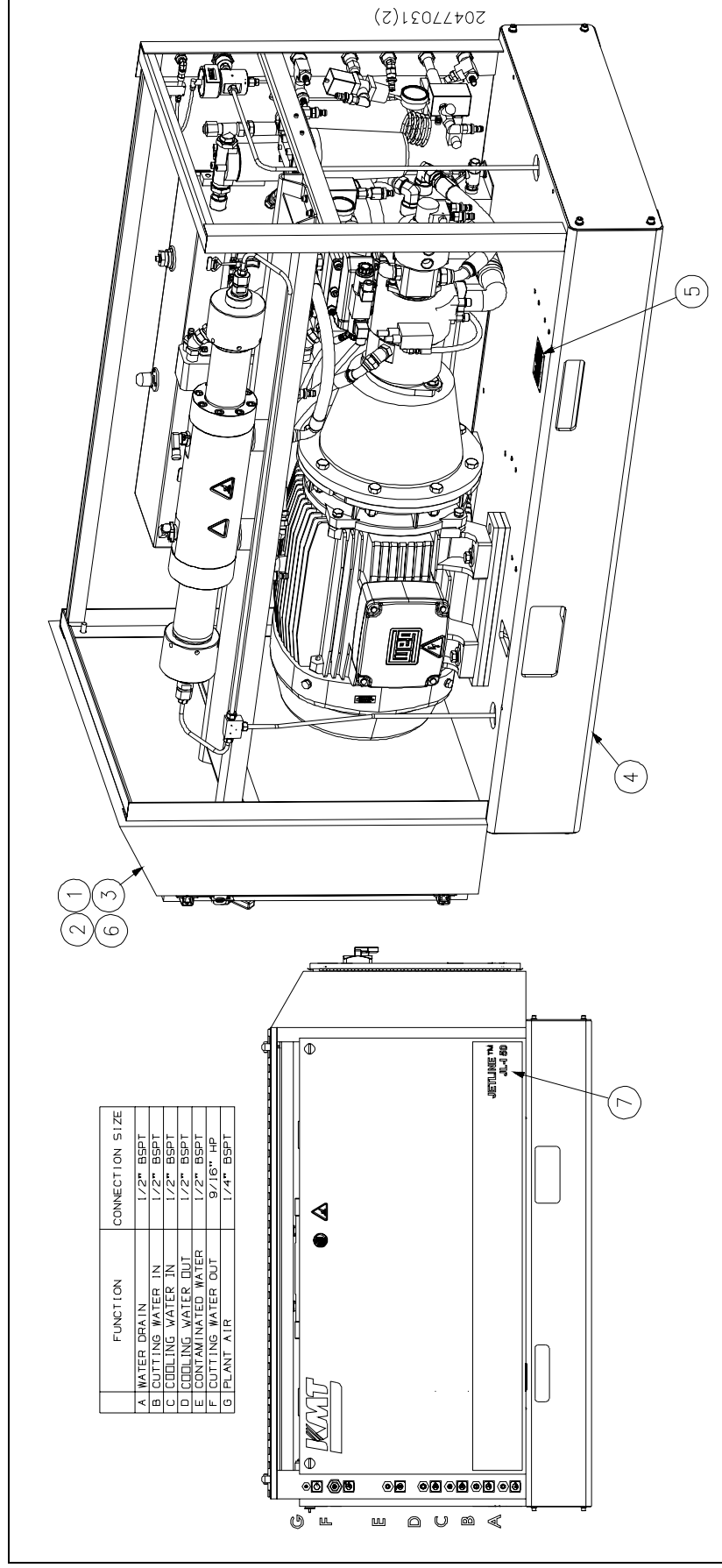




Table 12-2
Intensifier Assembly
20460873

Item	Part Number	Description	Quantity	Item	Part Number	Description	Quantity
1	05059712	High Pressure Cylinder	2	13	10110401	Collar, Sealing Head	2
2	05039771	Plunger	2	14	05034798	Retaining Ring	2
3	05116769	Sealing Head Assembly	2	15	05034764	Hydraulic Cylinder	1
4	05034772	Hydraulic Cylinder Head	2	16	10075000	O-Ring, 3.75 x 4.0 x .13	2
5	20422243	High Pressure Seal Assembly	2	17	05034855	Backup Ring	2
6	10110393	Sealing Head Seal Assembly	2	18	05141106	Socket Head Screw, M14 x 60	16
7	05059688	Soft Seal End Cap	2	19	20453934	Proximity Switch	2
8	80086622	Hydraulic Cartridge Seal Assembly	2	20	10183572	Socket Head Screw, M6 x 1.0 x 22MM	4
9	05007786	Bushing Retainer Flange	2	21	72112358	Hydraulic Piston Assembly	1
11	20497767	Liner, High Pressure Cylinder	2	23	05144183	Spacer, Proximity Switch	2
12	10074904	O-Ring, 1.56 x 1.75 x .09	4				

Figure 12-2: Intensifier Assembly

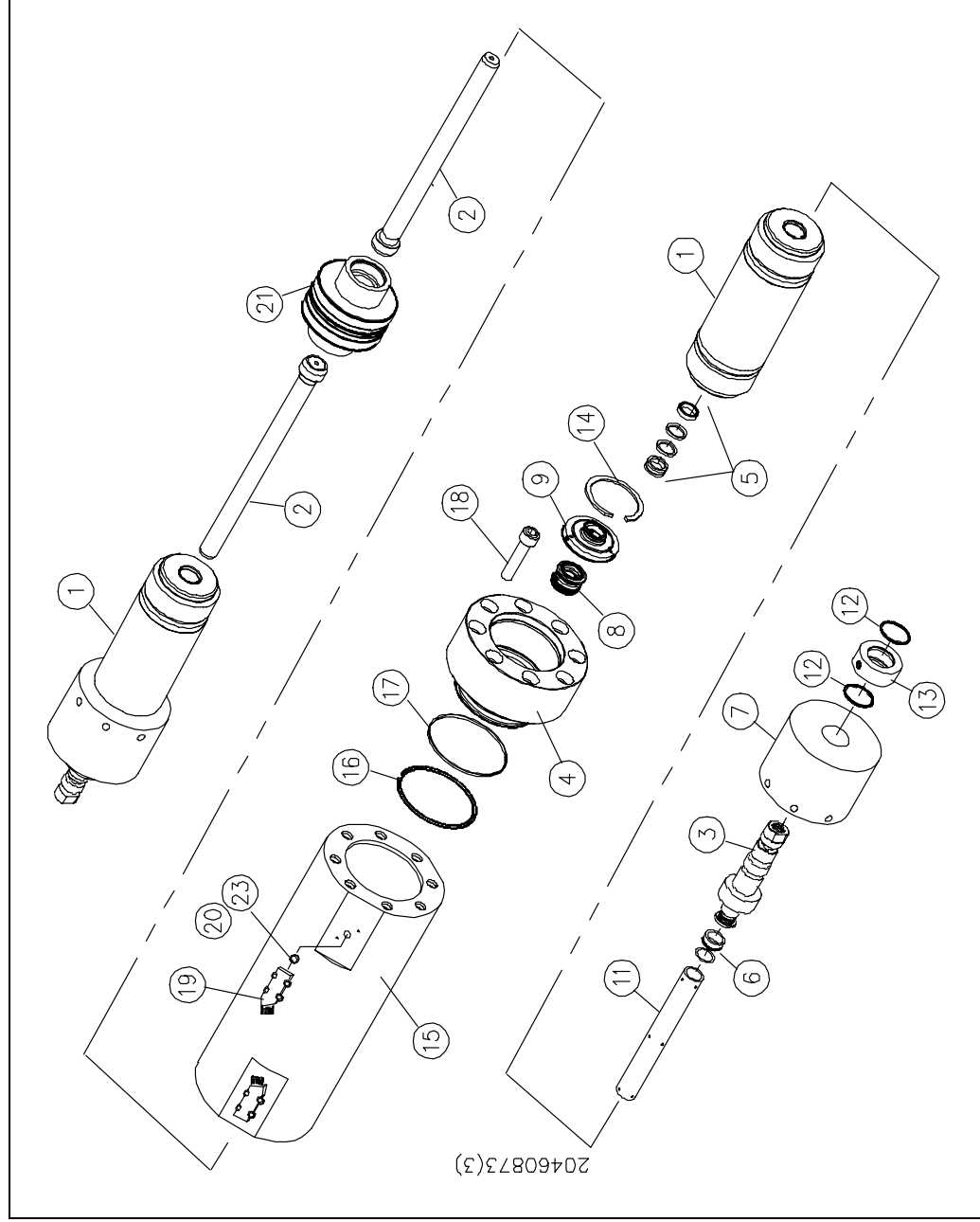


Table 12-3
Hydraulic Cartridge Seal
80086622

Item	Part Number	Description	Quantity
1	80086630	Seal Bushing	1
2	05015060	Packing Ring	1
3	10193522	O-Ring, 1.19 x 1.38 x .09	1
4	05050760	Backup Ring, 1.188 x 1.375	1
5	05129481	O-Ring, 1.0 x 1.13 x .06	1
6	05013024	O-Ring, 1.25 x 1.38 x .06	1
7	05129515	Backup Ring, 1.127 x .891	1
8	05027255	Packing Seal, U-Cup	1

Figure 12-3: Hydraulic Cartridge Seal

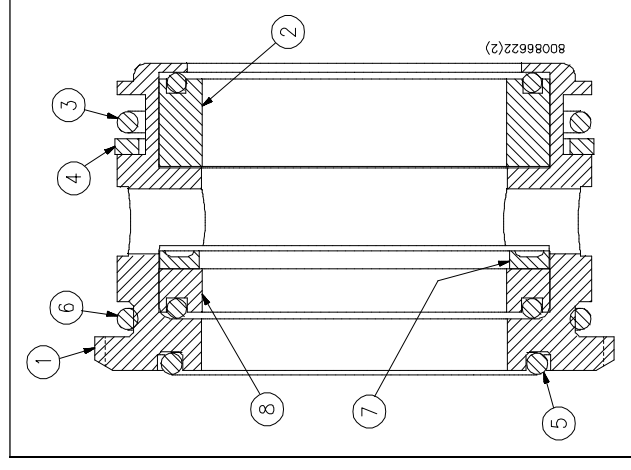


Table 12-4
Sealing Head Assembly
05116769

Item	Part Number	Description	Quantity
1	10106417	Sealing Head Body	1
2	10107894	Inlet Poppet Check Valve	1
3	05116777	Gland Nut	1
4	05112768	Seat	1
5	05116561	Discharge Poppet Check Valve	1
6	10118552	Poppet Retainer	1
8	49884562	Compression Spring	1
9	05116751	Poppet Pin	1
10	AV500260	Compression Spring	1

Figure 12-4: Sealing Head Assembly

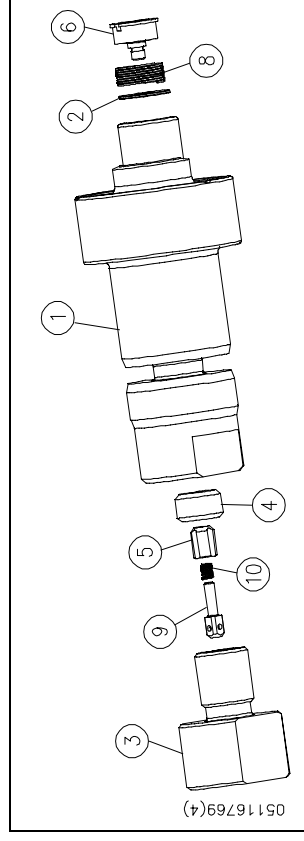




Table 12-5
Pneumatic Valve/Actuator Assembly, Normally Open
20427739

Item	Part Number	Description	Quantity	Item	Part Number	Description	Quantity
1	20427648	Valve Body	1		10189553	Actuator Assembly, Normally Open	
2	10178697	Valve Seat	1	7	BV401184	Pneumatic Cylinder	1
3	49830904	Adapter, HP Water Valve	1	8	BV601184	Cylinder Head	1
4	20435636	Valve Stem	1	9	BV501184	Piston	1
5	10188233	Backup Ring, Brass	1	10	10187250	Backup Ring, SST	1
6	20428052	Seal Assembly	1	11	10074714	O-Ring, 2.44 x 2.63 x .09	1
				12	10074565	O-Ring, 2.25 x 2.38 x .06	2



Table 12-6
Hydraulic Piston Assembly
72112358

Item	Part Number	Description	Quantity
1	72111944	Ram Piston	1
2	20498800	Plunger Retainer	2
3	20418031	Retaining Ring	2
4	05087713	O-Ring, 1.25 x 1.50	2
5	05049994	Backup Ring, 1.25 x 1.50	2
6	05117965	Seal Assembly	1
7	05117940	Bearing	2

Figure 12-6: Hydraulic Piston Assembly

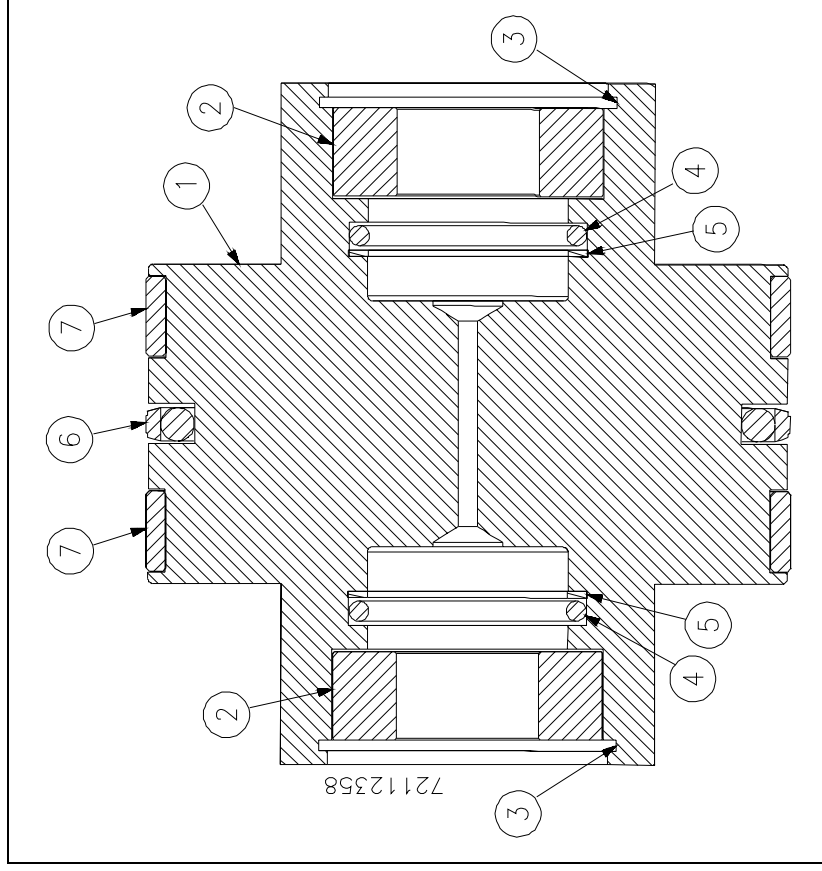




Table 12-7
High Pressure Water Assembly
20476916

Part			Part		
Item	Number	Description	Item	Number	Description
Quantity			Quantity		
1	20460873	Intensifier Assembly	17	49830581	Coupling, Bulkhead, .56 x .38
2	20467648	HP Tube, Bent, .25	18	20455068	Socket Head Screw, M12 x 1.75 x 20
3	80070311	HP Tube, Bent, .38	19	72102593	Clamp, Attenuator
4	10078715	HP Collar, .38	20	10094704	HP Tube, .38 x 3.0
5	10078129	HP Gland, .38	21	10083897	Ferrule, .25
6	10078590	Tee, HP, .38	23	10078459	HP Gland, .25
7	80070303	HP Tube, Bent, .38	24	10078426	HP Collar, .25
9	95413696	Lock Washer, .50	25	20427994	Socket Head Screw, M10 x 1.50
10	95383790	Socket Head Screw, 1/2-13 x 1	26	20427804	Intensifier Support, 3.0
11	72102577	HP Tube, Bent, .38	27	10074409	O-Ring, 1.0 x 1.25 x .13
12	10079531	Coupling, HP/HP, .56 x .38	28	05061486	Lock Washer, M10
13	20498314	Attenuator Assembly, .96L	29	05081872	Gasket
14	10078780	Elbow, HP, .38 x .38	30	10105443	HP Tube, .38 x 4.0
15	72102585	HP Tube, Bent, .38			
16	20427739	Valve/Actuator Assembly			

Figure 12-7: High Pressure Water Assembly

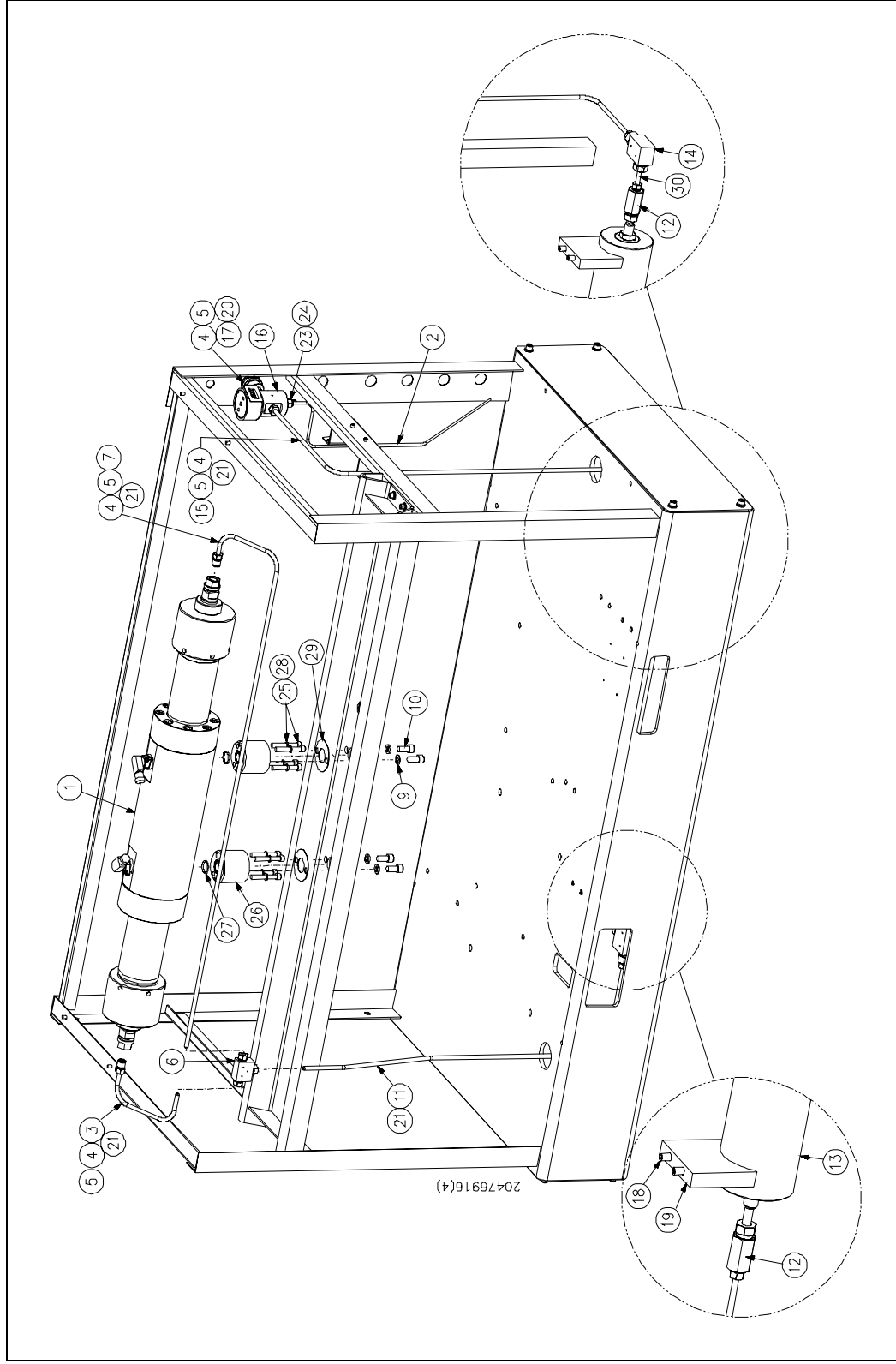




Table 12-8
Low Pressure Water Filter Assembly
20454810

Part			Part		
Item	Number	Description	Item	Number	Description
1	20468959	Plug, Pipe, .25	11	20468982	Check Valve
2	10069797	Flat Washer, #6	12	20468991	Adapter, BSPT/Hose, .50 x .50
3	20469505	Relief Valve	13	10069888	Lock Washer, #6
4	20468963	Nipple, BSPT, .75	14	10106722	Filter Element, 10 Micron
5	20468967	Elbow, BSPT, .50 x .50	15	10070183	Hex Nut, M6
6	20468646	Manifold, Outlet	16	10078152	Bushing, Pipe, .75 x .50
7	10081230	Elbow, Pipe, .75 x .75	17	20468955	Adapter, BSPT/JIC, .50 x .50
8	20468970	U-Bolt, .75	18	20468724	Hose Barb, .50 x .50
9	20468974	Adapter, BSPT/Hose, .50 x .50			
10	20468978	Filter Housing Assembly			

Figure 12-8: Low Pressure Water Filter Assembly

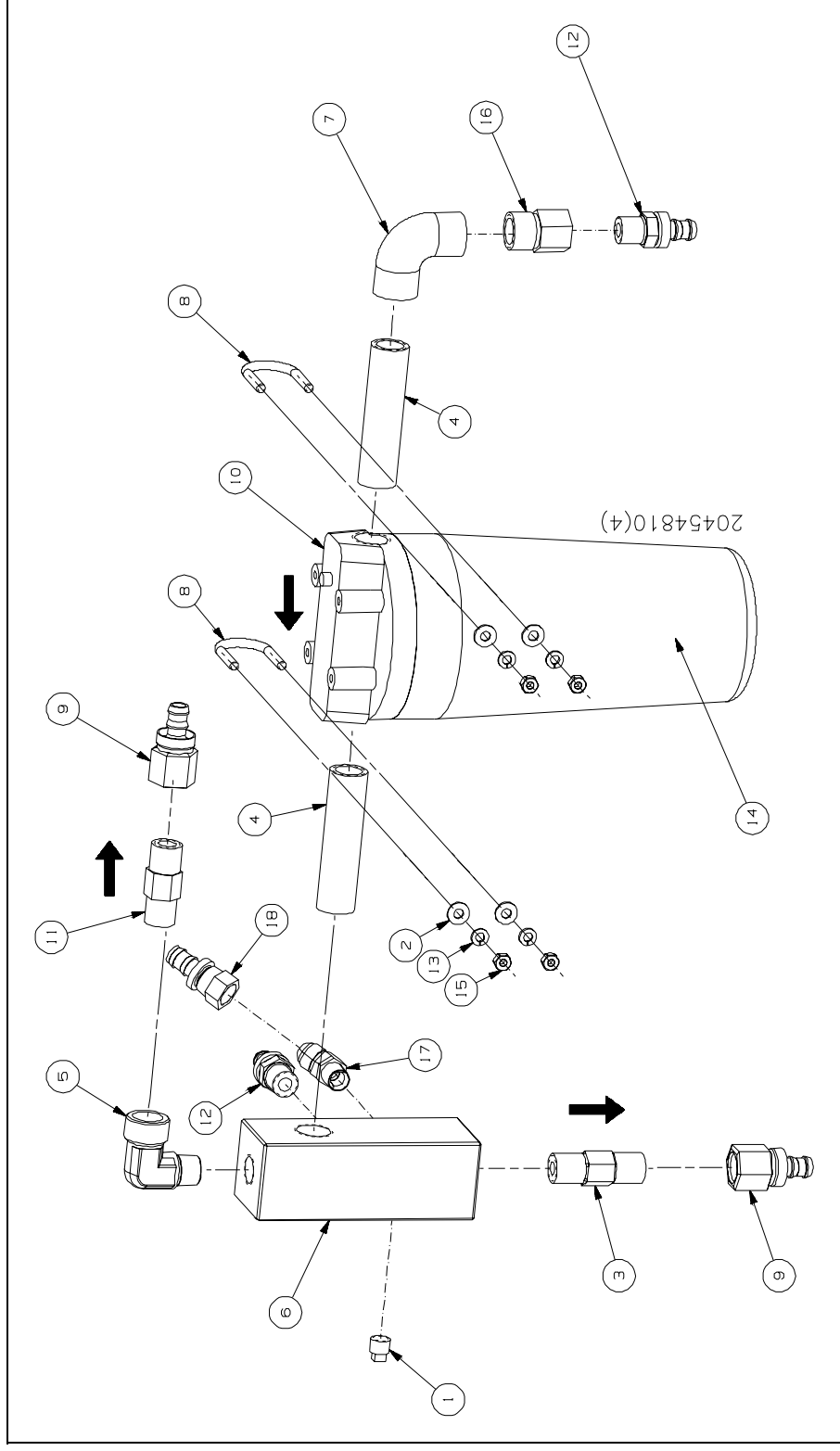




Table 12-9
Hydraulic Power Package
20476908

Part			Part		
Item	Number	Description	Item	Number	Description
Quantity			Quantity		
1	49890460	Electric Motor, 50HP	18	05045364	Gear Pump
2	10092302	Shaft Coupling	19	49892342	Flat Washer, M16
3	05049168	Adapter, Water Pump	20	49892375	Hex Head Screw, M16 x 2 x 60MM
4	10116952	Caplug, 1.04	21	20477284	Vibration Isolation Module
5	49887094	Water Pump, Vane	22	05037593	Socket Head Screw, M10 x 1.50 x 25MM
6	95838314	Lock Washer, .25	23	20432331	Socket Head Screw, M16 x 2 x 50MM
7	95572897	Hex Head Screw, 1/4-20 x 5/8	24	49892359	Lock Washer, M16
8	10069714	Flat Washer, .38	25	05139720	O-Ring, 85MM x 3MM
9	95750394	Lock Washer, .38	26	10091510	Arrow Decal
10	95416319	Hex Head Screw, 3/8-16 x 1	27	10144749	Adapter, JIC/ORB, .25 x .25
11	49883580	Flat Washer, M10	28	10142644	Adapter, JIC/ORB, .25 x .25
12	10064715	Lock Washer, M10	29	49833072	Lock Washer, .63
13	49886989	Adapter, JIC/Pipe, .50 x .38	30	20477758	Hex Head Screw, M18 x 2.50 x 70MM
14	10189025	Adapter, Hose/JIC, .50 x .50	31	20477800	Flat Washer, M18
15	20476925	Coupling, Flex Drive	32	20477803	Lock Washer, M18
16	20477006	Flange, Motor/Pump	33	20477807	Hex Nut, M18
17	20478196	Pump/Manifold Assembly			

Figure 12-9: Hydraulic Power Package

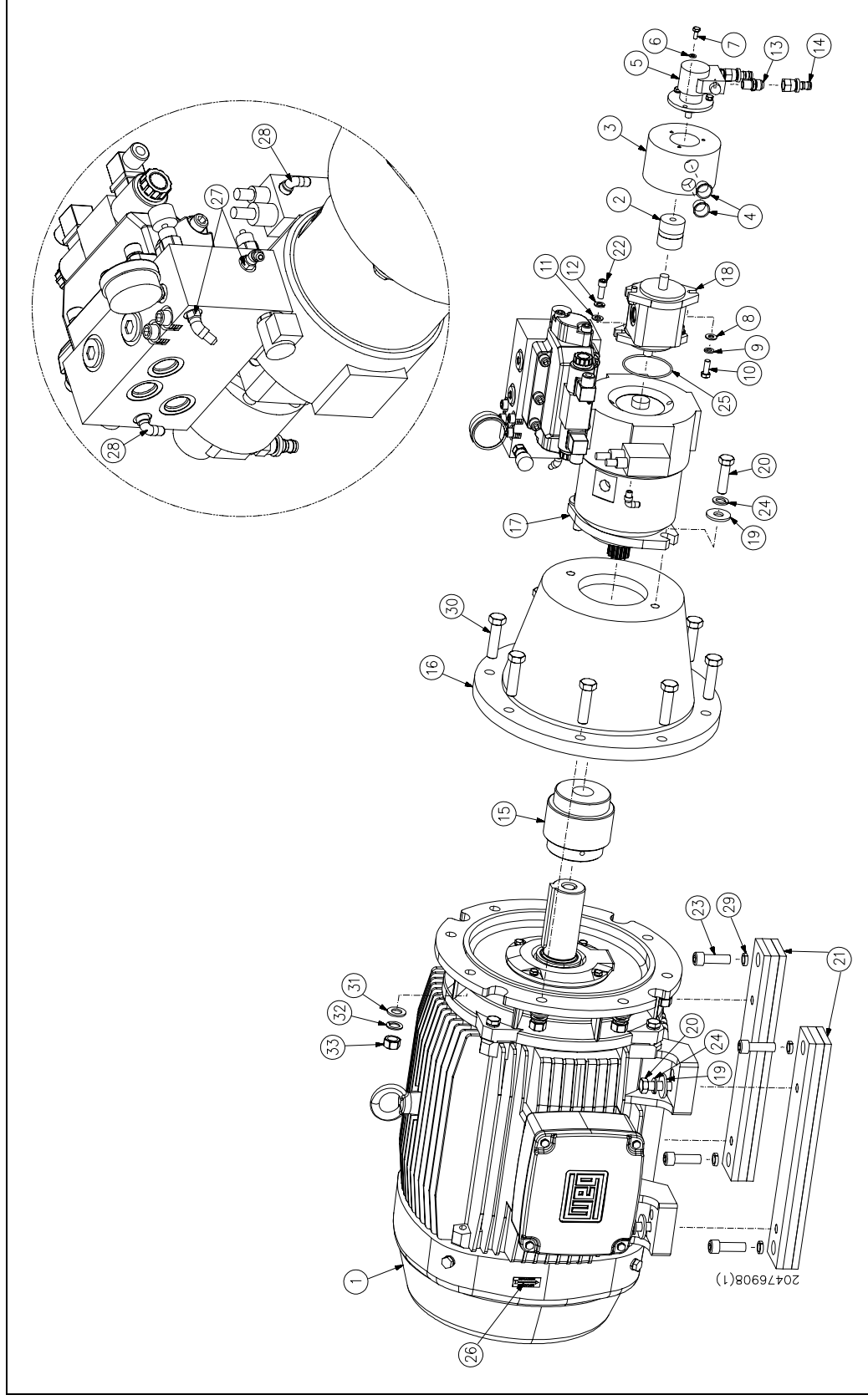




Table 12-10
Pump/Manifold Assembly
20478196

Item	Part		Quantity	Part		Quantity
	Number	Description		Number	Description	
1	05045505	Hydraulic Pump	1	11	05055017 Plug, ORB, .13	2
2	05044144	Manifold	1	12	10185585 Solenoid Valve	1
3	05091756	Socket Head Screw, 7/16-14 x 6	4	13	10187052 Relief Valve	1
4	05050356	Lock Washer, .44	4	14	10187060 Relief Valve	1
5	10074953	O-Ring, 1.50 x 1.75 x .13	1	15	49889744 Retainer, Cartridge Valve	1
6	05071717	Relief Valve	1	16	49889736 Check Valve	1
7	20437164	Directional Control Valve	1	17	49889769 Plug, ORB, .25	1
8	95055059	Socket Head Screw, 1/2-13 x 2-1/2	6	18	05089792 Flat Washer, .44	12
9	95688750	Lock Washer, .50	6	19	05045497 Pressure Gauge	1
10	05071055	Plug, ORB, .75	3			

Figure 12-10: Pump/Manifold Assembly

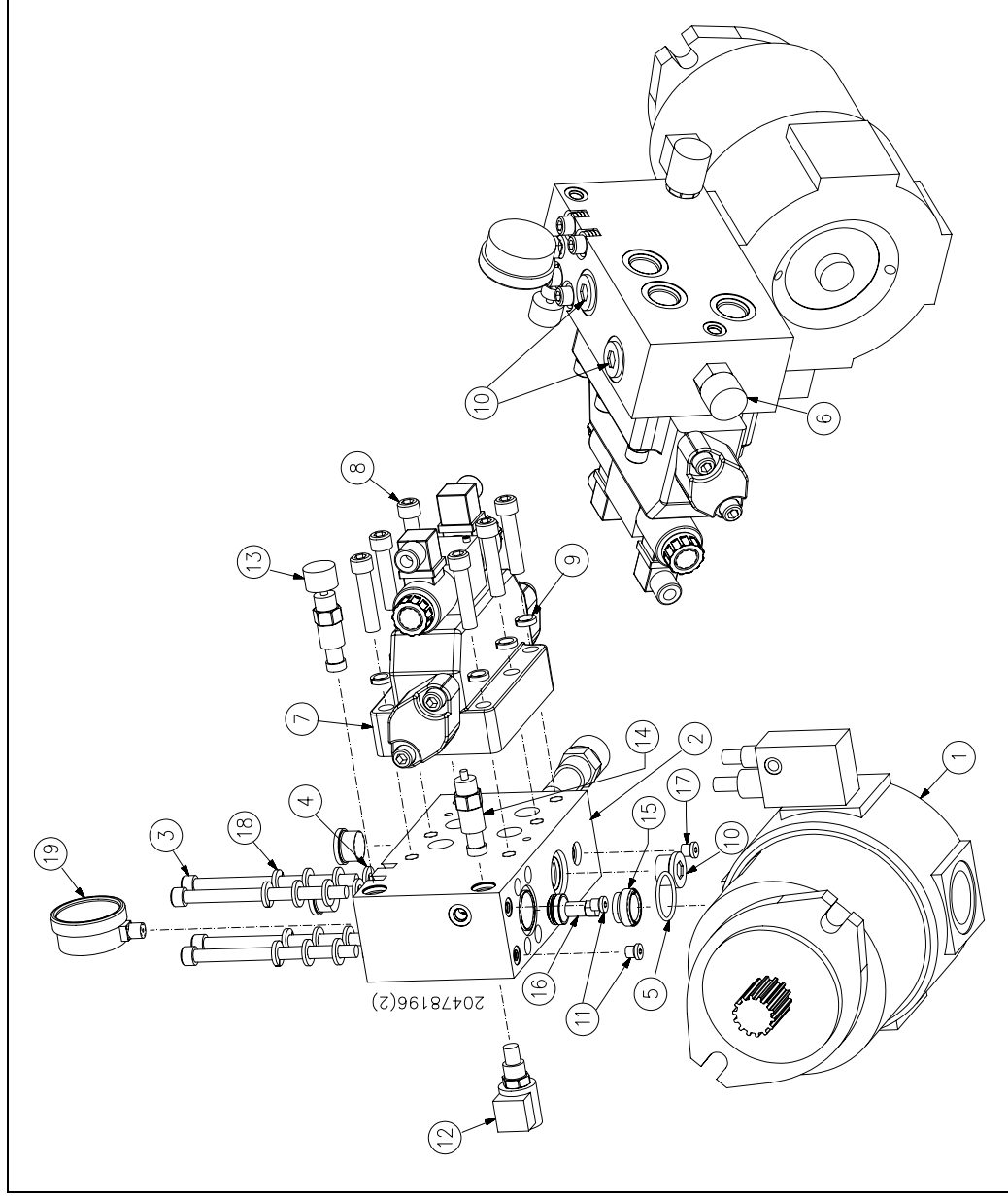




Table 12-11
Hydraulic Hose Connections
20477268

Part				Part			
Item	Number	Description	Quantity	Item	Number	Description	Quantity
1	20449078	Hose Assembly, Hydraulic, 1.0 x 15.50	1	10	05050331	Adapter, JIC/ORB, .75 x .63	2
2	10091163	Adapter, JIC/ORB, .75 x .75	1	11	05052493	Adapter, JIC/ORB, .75 x .63	1
3	10083517	Hose Clamp	2	12	95702619	Adapter, JIC/ORB, .75 x .75	2
4	10179018	Radiator Hose, 2.0	10.0"	13	05064407	Adapter, JIC/ORB, 1.0 x .75	1
5	05048780	Split Flange Kit, 2.0	1	14	80086192	Adapter, JIC/ORB, 1.0 x 1.0	1
6	05048806	Adapter, Flange/Hose, 2.0 x 2.0	1	15	05060751	Hose Assembly, Hydraulic, .25 x 32.0	2
7	20468826	Hose Assembly, Hydraulic, .75 x 23.0	1	16	10150688	Hose Assembly, Hydraulic, .25 x 24.0	1
8	20477713	Hose Assembly, Hydraulic, .75 x 29.0	2	17	20477869	Hose Assembly, Hydraulic, 1.0 x 19.0	1
9	20455089	Hose Assembly, Hydraulic, .75 x 29.0	2				

Figure 12-11: Hydraulic Hose Connections

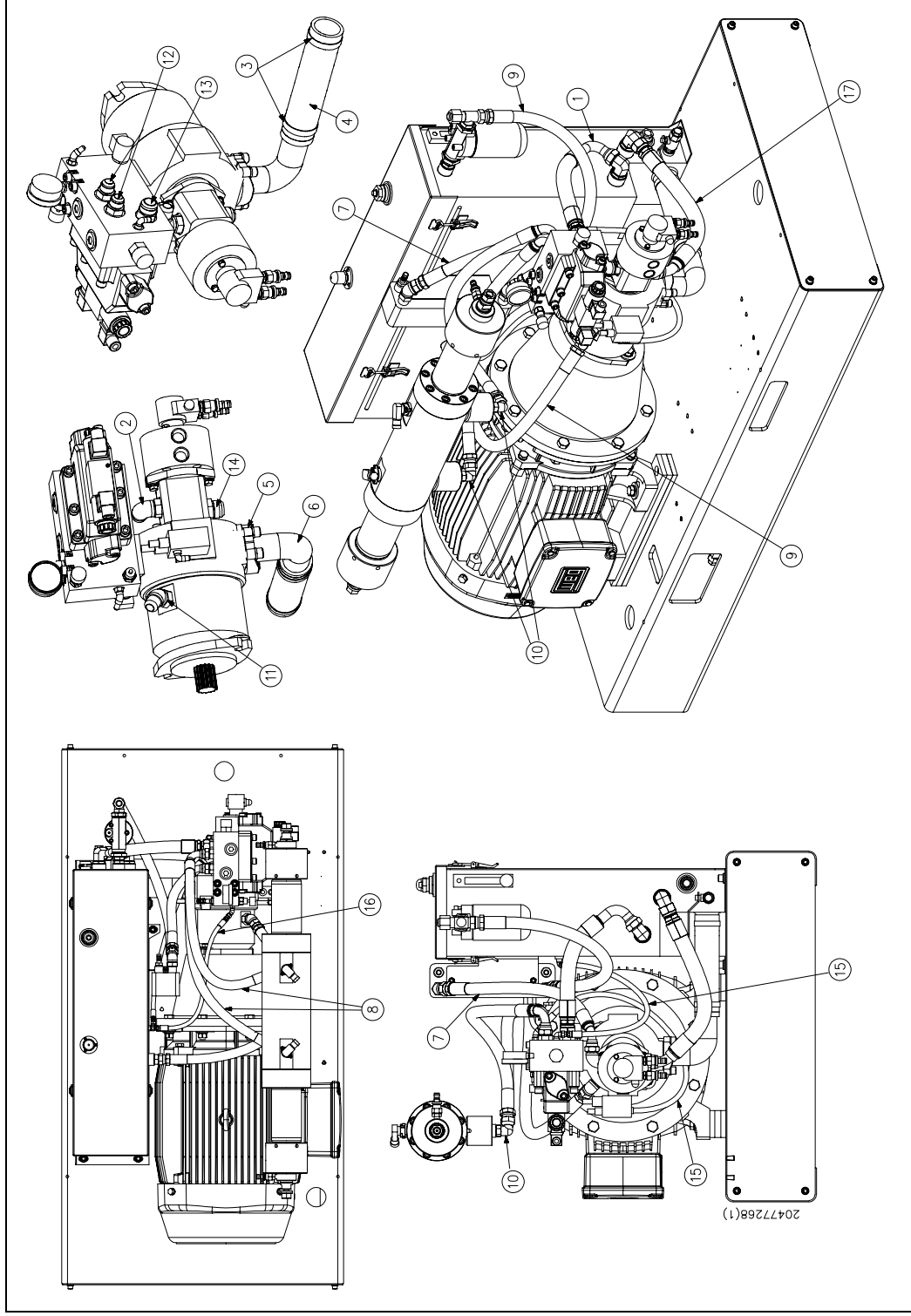




Table 12-12
Reservoir Assembly
20477035

Part			Part		
Item	Number	Description	Item	Number	Description
1	20478147	Reservoir Weldment	16	20468708	Adapter, BSPT/JIC, .25 x .25
2	20478151	Reservoir Lid	17	20468711	Adapter, BSPT/JIC, .75 x .75
3	20462991	Gasket	18	10070191	Hex Nut, M8
4	20468655	Gauge, Level/Temperature	19	10069672	Lock Washer, M8
5	20476941	Adapter, BSPT/ORB, .75 x .75	20	20477570	Adapter, JIC/BSPT, .75 x .50
6	20468662	Filter Head, Hydraulic	21	20470406	Hose Barb, .50 x .50
7	20468666	Filter Element	22	20479720	Adapter, BSPT/JIC, .25 x .25
8	20468670	Tee, BSPT/JIC, .75 x .75	23	20468732	Heat Exchanger
9	05069976	Cap, JIC Swivel, .75	24	20468736	Air Breather
10	20468683	Adapter, BSPT/JIC, .75 x .75	25	05050026	Switch, Temperature/Level
11	80087687	Diffuser	26	20468740	Bushing, BSPT, 1.25 x .75
12	20468687	Bulb Well	27	10134278	Socket Head Screw, M12 x 1.75 x 25MM
13	20468691	Ball Valve, 2-Way	28	49898729	Flat Washer, M12
14	20468695	Plug, BSPT, .50	29	49883499	Lock Washer, M12
15	20468704	Adapter, BSPT/JIC, 1.0 x 1.0	30	10191484	Pan Head Screw, M5 x 10MM

Figure 12-12: Reservoir Assembly

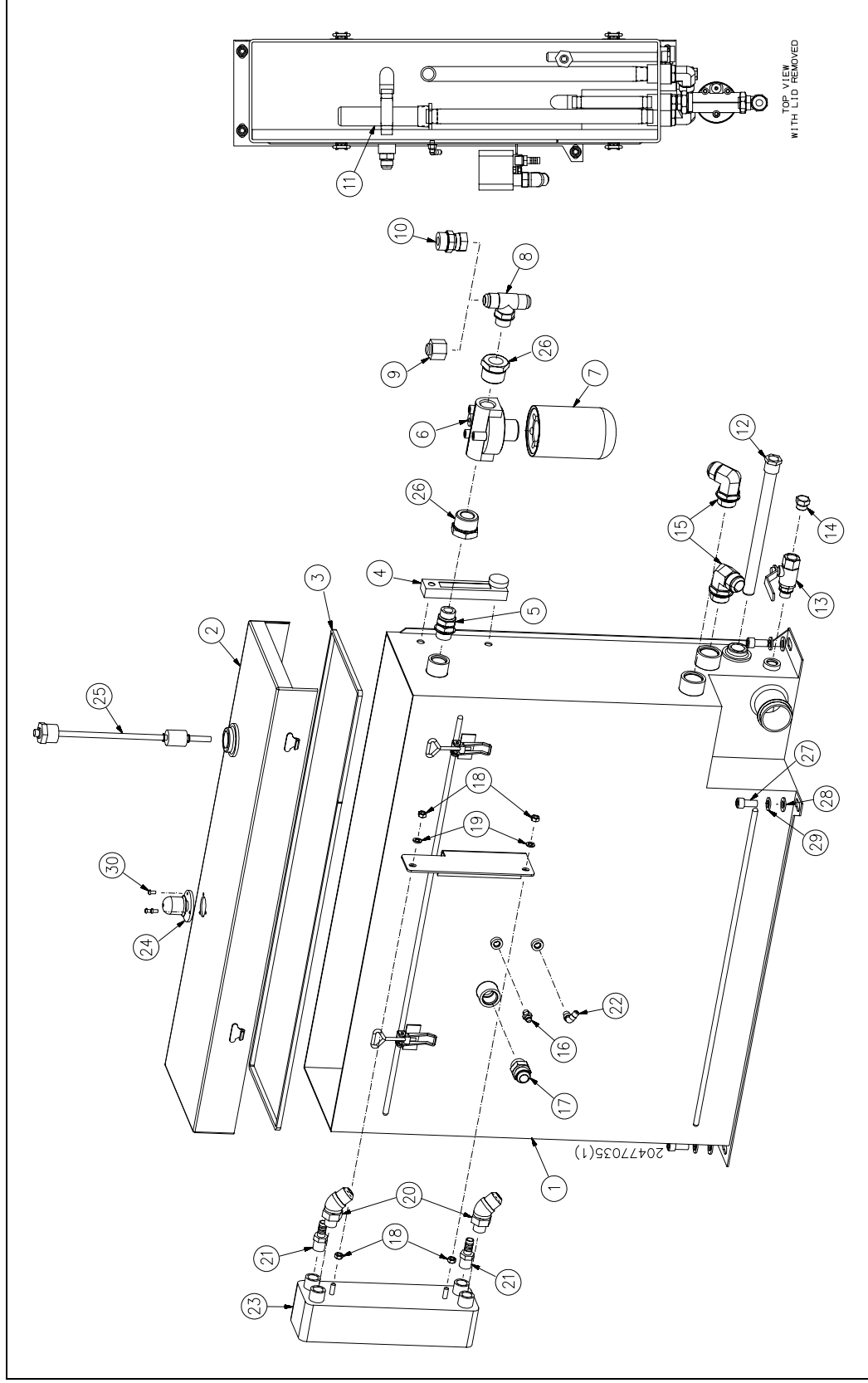




Table 12-13
Bulkhead Pipe Assembly
20477264

Part				Part			
Item	Number	Description	Quantity	Item	Number	Description	Quantity
2	20468724	Hose Barb, .50	6	20	20469054	Adapter, BSPT/Tube, .50 x .50	1
3	20454810	Filter Assembly, LP Water	1	21	20469063	Water Modulating Valve	1
4	05142062	Pressure Switch, 60 psi	1	22	20469066	Adapter, BSPT/JIC, .50 x .50	2
5	20469501	Pressure Gauge, 0-200 psi	1	23	20469070	Nipple, BSPT, .50 x 3.0	1
6	20469497	Coupling, Bulkhead, .94 x .25	1	24	20469074	Solenoid Valve	1
7	20469488	Coupling, Bulkhead, BSPT, 1.50 x .50	5	25	20469083	Nipple, BSPT, .50 x 2.0	2
8	10070092	Jam Nut, 1-14	5	26	20468642	Manifold, LP Water	1
9	20468995	Elbow, BSPT, .12 x .25	1	27	20469484	Pressure Gauge, 0-100 psi	1
10	20469007	Check Valve	1	29	05140751	Pressure Switch, 30 psi	1
11	20469016	Solenoid Valve	1	30	20469091	Filter, Strainer	1
12	20469020	Coupling, Tube, 6MM x .12	1	31	20421272	Hose, Push-On, .50	300.0"
13	20469023	Poly Tube, 6MM	12.0"	32	05111406	Adapter, JIC/Pipe, .50 x .25	2
14	20469027	Adapter, Tube/Pipe, 6MM x .13	1	33	49834328	Adapter, Pipe/Tube, .50 x .25	1
15	20469031	Tee, BSPT, .50 x .50	1	34	20470149	Adapter, JIC/BSPT, .50 x .50	2
16	20469035	Elbow, BSPT, .50 x .50	1	35	20469985	Jam Nut, 3/4-16	1
17	20470406	Hose Barb, .50	3	36	20469989	Nipple, BSPT, .12 x .12	1
18	20469039	Nipple, BSPT, .50	1				
19	20469042	Adapter, BSPT/Tube, .50 x .50	1				

Figure 12-13: Bulkhead Pipe Assembly

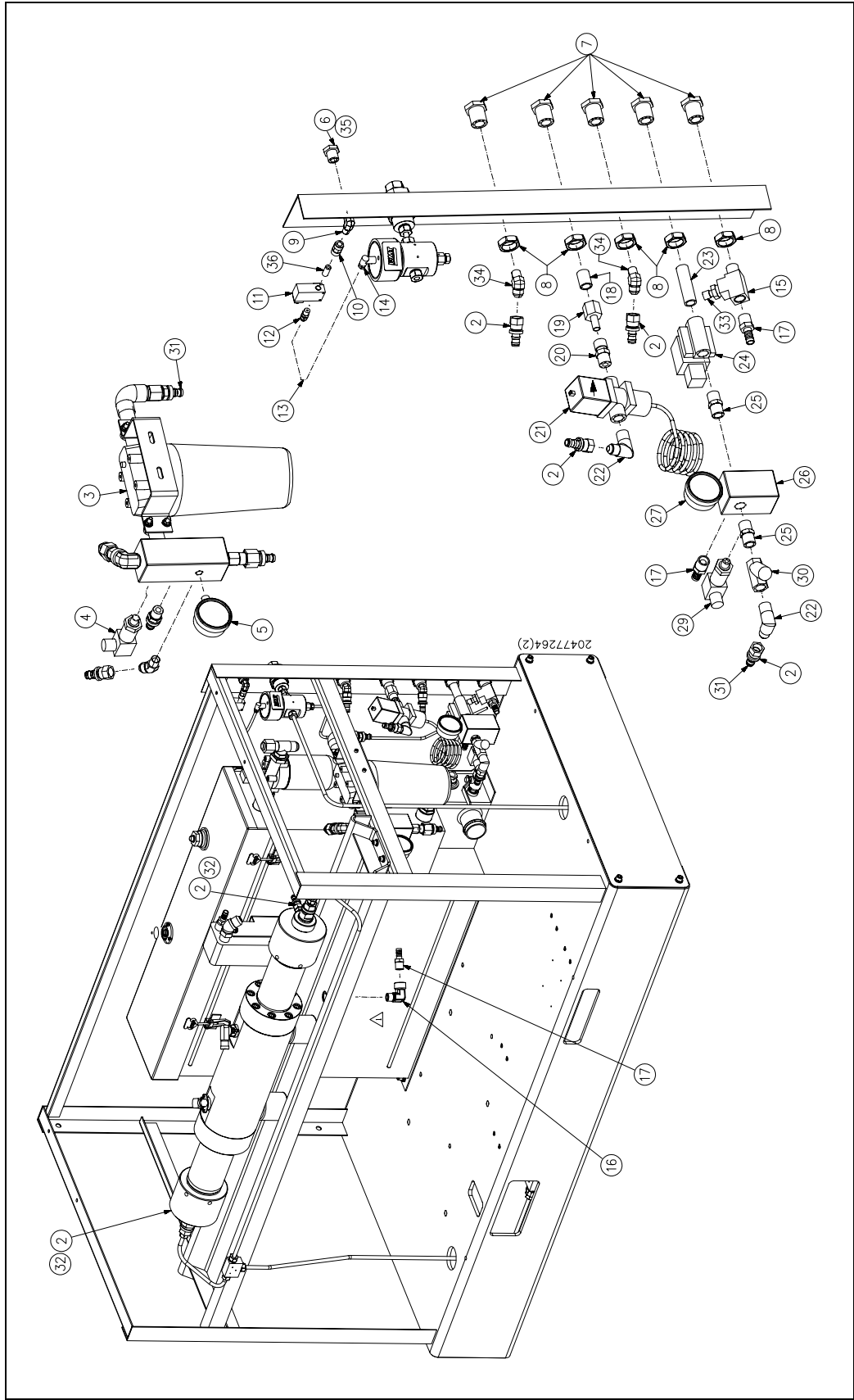




Table 12-14
Electrical Assembly
20477742

Item	Part Number	Description	Quantity
1	20468572	Harness, Sensor/Solenoid	1
2	20469123	Connector, Flexible Conduit, 1.50	1
3	05141700	Ring Terminal, #8	2
4	20469132	Flex Conduit, 1.50	22.0"
5	20469136	Connector, Flexible Conduit, 1.50	1
6	95423695	Hex Nut, 1/2-13	4
7	20470325	Terminal Lug, #14-2/0	6
8	10069763	Flat Washer, .50	4
9	20468875	Wire, 10MM, Black	276.0"
10	20477288	Cable, 9MM	48.0"
11	20468427	Connector, Crimp Ferrule, #8	18
12	95716890	Lock Washer, .50	4
13	10125912	Cable Tie	5
14	20477068	Electrical Configuration	1

Figure 12-14: Electrical Assembly

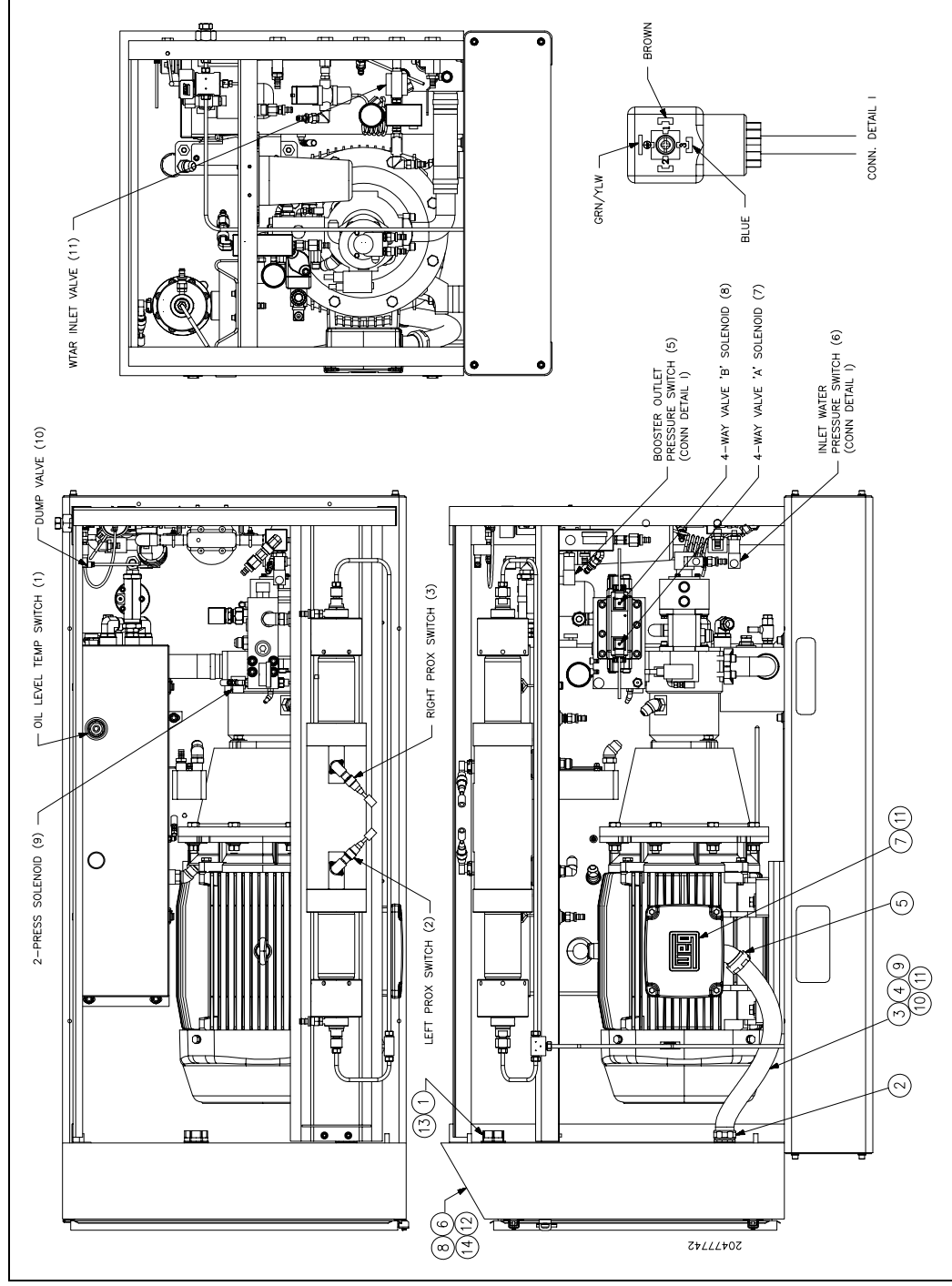




Table 12-15
Electrical Configuration
Wye-Delta
20477068

Item	Part		Description	Quantity	Part		Description	Quantity
	Number				Item	Number		
1	20477059		Circuit Breaker, 100A	1	18	20468416	Connector, Crimp Ferrule, #14	8
2	05081955		Socket Head Screw, 8-32 x 2	4	19	20468235	Circuit Breaker, 2A	1
3	20468452		Rotary Drive, Circuit Breaker	1	20	20468875	Wire, 10MM, Black	72.0"
4	20468448		Breaker, Terminal Cover	2	21	20468427	Connector, Crimp Ferrule, #8	6
5	05141650		Ground Lug, #4-#0	4	22	204770555	Contact, 50A	2
6	20468420		Ground Lug	2	23	20473532	Overload Relay	1
7	10167070		Pan Head Screw, 8-32 x 1	8	24	20470103	Contact, 32A	1
8	95750469		Lock Washer, #8	8	25	20477632	Auxiliary Contact Block	2
9	95146429		Hex Head Screw, #8-32	4	26	20470137	Interlock, Contactor	1
10	20477288		Cable, 9MM	110.0"	27	20470128	Buss Bar	1
11	05141700		Ring Terminal, #8	4	28	20477048	Kit, Star Delta Wiring	1
12	20468313		Terminal Block	1	29	80078223	End Block, #22-#10	10
13	20468440		DIN Rail	77.0"	30	20468239	Transformer, 200VA, 230VAC	1
14	10073492		Pan Head Screw, 8-32 x 1/2	33	31	20468900	Wire, 1.5MM, Red	160.0"
15	10069730		Flat Washer, #8	33	32	20468424	Connector, Crimp Ferrule, #16	250
16	20468346		Wiring Duct	148.0"	33	20469108	Circuit Breaker, 1A	1
17	20468892		Wire, 2.5MM, Black	60.0"	34	20470165	Relay, Wye-Delta Timing	1



Table 12-15
Electrical Configuration
Wye-Delta
20477068

Part				Part			
Item	Number	Description	Quantity	Item	Number	Description	Quantity
35	20468403	Power Supply, 24VDC	1	52	20468288	PLC-S7200	1
36	20468896	Wire, 1.5MM, Blue	1040.0"	53	20468350	Memory, PLC EEPROM	1
37	20468904	Wire, 1.5MM, Blue/White	240.0"	54	20468342	PLC Battery	1
38	20468883	Wire, 1MM, Yellow/Green	80.0"	55	20468297	Connector, Profibus	1
39	80078207	Terminal Block, #24-#10	9	56	20468301	Cable, Profibus	48.0"
40	20468395	Circuit Breaker, 6A	1	57	20468309	Display, OP73	1
41	20468391	Switch, E-Stop	1	58	20468260	Selector Switch, 2 Position	1
42	20468378	Legend Plate	1	59	20468252	Legend Plate	1
43	20468375	Terminal Block, #14-22	79	60	20468382	Contact Block	1
44	20468371	End Barrier	2	61	20468326	Pilot Light, Red	1
45	20468367	Jumper, Terminal Block	5	62	20468284	Pilot Light, Green	1
46	20468358	Marker, Terminal Block	16	63	20468322	Spiral Wrap	12.0"
47	20468305	Terminal Block	7	64	20468280	Hole Seal, 20MM	10
48	20468248	Relay Base	2	65	20468273	Hole Seal, 50MM	2
49	20468256	Tube Base Relay	2	66	20468354	Subplate	1
50	20468264	Switch, Pushbutton	1	67	20468333	Ring Terminal, 14-10	3
51	20468277	Block, Lamp Socket	1	68	20470141	Auxiliary Contact Block	2

